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Graptolite Faunas of the Marathon Region, West Texas

WILLIAM B. N. BERRY

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS, AUSTIN
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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

SAM HOUSTON

Cultivated mind is the guardian genius of Democracy, and while guided and controlled by virtue, the noblest attribute of man. It is the only dictator that freemen acknowledge, and the only security which freemen desire.

MIRABEAU B. LAMAR

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Contents

Illustrations

Tables

Graptolite Faunas of the Marathon Region, West Texas

WILLIAM B. N. BERRY[1]

ABSTRACT

In the Marathon region, graptolites have been found throughout a 2,000-foot section of limestones and shales from the base to the top of the Ordovician system. This is the most complete sequence of Ordovician graptolites known in North America. Fifteen faunal zones are recognized. This region will provide a standard section against which other graptolite-bearing formations may be compared.

Other graptolite-bearing formations in North America are correlated with the Marathon zones. Further, the Marathon zones are correlated with the British and Australian Ordovician graptolite zonal successions. The zonal assemblages in the Marathon region for the Lower and lower part of the Middle Ordovician are similar to the Australian but differ from the British. The upper part of the Middle Ordovician and the Upper Ordovician assemblages are nearly identical in all three zonal sequences.

The report includes an extension of detailed stratigraphic study to lesser-known areas southeast and southwest from the Marathon basin. P. B. King mapped the basin in detail and recognized five Ordovician formations. From oldest to youngest these are the Marathon limestone, Alsate shale, Fort Peña formation, Woods Hollow shale, and Maravillas chert. The boundaries of the Marathon limestone and Alsate shale are modified from King's (1937) usage. Also, a progressive change to a more arenaceous nature southward from the basin is noted for the lower part of the section, and a new formation, the Rodriquez Tank sandstone, is recognized in the southern exposures.

The stratigraphic position of every species of graptolite found in the Marathon region is correlated with occurrences of these species elsewhere in North America and in England and Australia. Seven new species of graptolites are described.

INTRODUCTION

Scope of the Study

The Ordovician rocks in the Marathon basin have long been a subject of considerable interest, and since publication of King's (1937) Professional Paper on the area, they have been under study by personnel of oil companies, summer field camps, and field conferences. Graptolites have been known from the sequence for over 50 years, and Udden, Baker, Bowman, and King all made collections from it. However, no systematic study of the fauna has been made. Furthermore, exposures of Ordovician rocks southeast and southwest of the basin have never been adequately described. The present work is a detailed stratigraphic and paleontologic study of the Ordovician strata and fauna in the entire Marathon region.

The field work was carried out during the summers of 1954 and 1955, and the laboratory work was done at Yale University during the academic year 1955–1956 and at Harvard University during the summer of 1956. The area studied includes the Marathon basin and the old Jones ranch (now Slaughter ranch), Persimmon Gap, Rough Creek, and Solitario localities as shown on the index map (fig. 1). King's geologic maps were used as a base and

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attention was concentrated on making as many collections of fossils as possible that were accurately located stratigraphically.

The major portion of the collections is at Yale Peabody Museum. The types of new species and nearly all of the figured specimens are deposited there and have Yale Peabody Museum (YPM) catalogue numbers as indicated on the plate captions. Smaller, but representative, collections have been given to Professor H. B. Whittington at the Museum of Comparative Zoology at Harvard University, and to Professor O. M. B. Bulman at the Sedgwick Museum at Cambridge University.

Acknowledgments

The writer is indebted to Professor Whittington for suggesting this project and for continued encouragement and guidance. Professor C. O. Dunbar supervised much of the research and critically read the manuscript. Dr. J. L. Wilson visited the writer in the field and gave valuable suggestions on all phases of the work. Professor J. E. Sanders discussed certain vexing problems and made valuable criticisms. The writer is also indebted to Professor Bulman for checking the identifications of a representative collection of graptolites and for comments on the intercontinental correlations. The writer expresses grateful thanks to: Dr. C. E. Decker for permitting examination of the collections at the University of Oklahoma and for discussing correlations; Dr. William Ham for advising on the correlation of the Arbuckle sequence with the Marathon; Professor R. W. Harris and Mr. M. E. Upson for aiding in the identification of the ostracods and discussing the correlation of the Arbuckle and Marathon successions; Professors Paul Fan, J. P. Brand, and Richard Rush for suggesting collecting localities and discussing the stratigraphy; Dr. William Pitt for spending several days guiding him through the Ouachita Mountains; Mr. H. M. Nielson and Dr. W. Hess for making the facilities of the Gulf Oil Corporation field party available and for discussing the stratigraphy in the field; Mr. Clinton Kilfoyle for making available for study Dr. Ruedemann's collections at the New York State Museum in Albany, New York; and Dr. G. Arthur Cooper for permitting the study of the Marathon region graptolite collections at the U. S. National Museum.

The writer was ably assisted in the field by David B. Clarke during the first summer and by Martin D. Collins, Jr., during the second. The large collections would not have been possible without their enthusiastic aid.

This project was made possible by a Broderick Fund grant from the Department of Geology at Harvard University to cover the expenses of the first summer, and by a research grant from Shell Research and Development Company for the completion of the work. It was presented as a dissertation for the degree of Doctor of Philosophy at Yale University in May 1957.

Previous Work

R. T. Hill in 1900 gave the first brief summary of pre-Carboniferous rocks in the Marathon region. He noted "closely folded Paleozoic limestone, shales and cherts, probably of lower Helderberg age." Udden (1907) traveled across the Marathon basin during the course of his investigation of the geology of the Chisos country and described the highly folded and faulted dark shales, limestone, and cherts. He collected some fossil fragments from ledges of bituminous limestone exposed "along the wagon road near Ridge Spring and at different points south from this place for a distance of ten miles." The fossils were sent to Charles Schuchert, who identified *Trinucleus, Plectambonites, Rafinesquina,* and a possible *Zygospira* (Udden, 1907). Dr. Schuchert considered the fossils to be of Trenton age.

The first comprehensive stratigraphic work in the area was that of Baker and Bowman (1917), who in 1915 collected fossils and made brief studies of the pre-Carboniferous succession. E. O. Ulrich studied the fossils and recognized six dis-

tinctive faunas in the collections. Baker and Bowman divided the pre-Carboniferous section into four formations on the basis of the fossil determinations and the lithology.

In 1929 and 1930, P. B. King made a regional study of the entire Marathon area and mapped two quadrangles in detail. He restudied the Ordovician rocks carefully, measuring seventeen sections and making fossil collections. A small part of the fauna collected was studied by Kirk, Ulrich, and Ruedemann. King (1931, 1937) divided the Ordovician section into five formations and described the rocks in detail. His now classic "Geology of the Marathon region, Texas," remains as the standard work on the geology of this region and has formed the basis from which road logs and articles have been written for several field trip guidebooks of the West Texas Geological Society (Maxwell et al., 1941, 1949; Adams et al., 1952; Lonsdale et al., 1955).

Recently, Wilson (1954a, 1956) described trilobite faunas from the Upper Cambrian–Lower Ordovician beds of the Dagger Flat and Marathon formations and from exotic boulders of the same age near the top of the Middle Ordovician Woods Hollow shale. Wilson (1954b) extended the pre-Carboniferous stratigraphy described by King for the Marathon basin proper to less known outcrops in the Solitario, Persimmon Gap, and old Jones ranch area which lie respectively southwest, south, and southwest from the well-known basin.

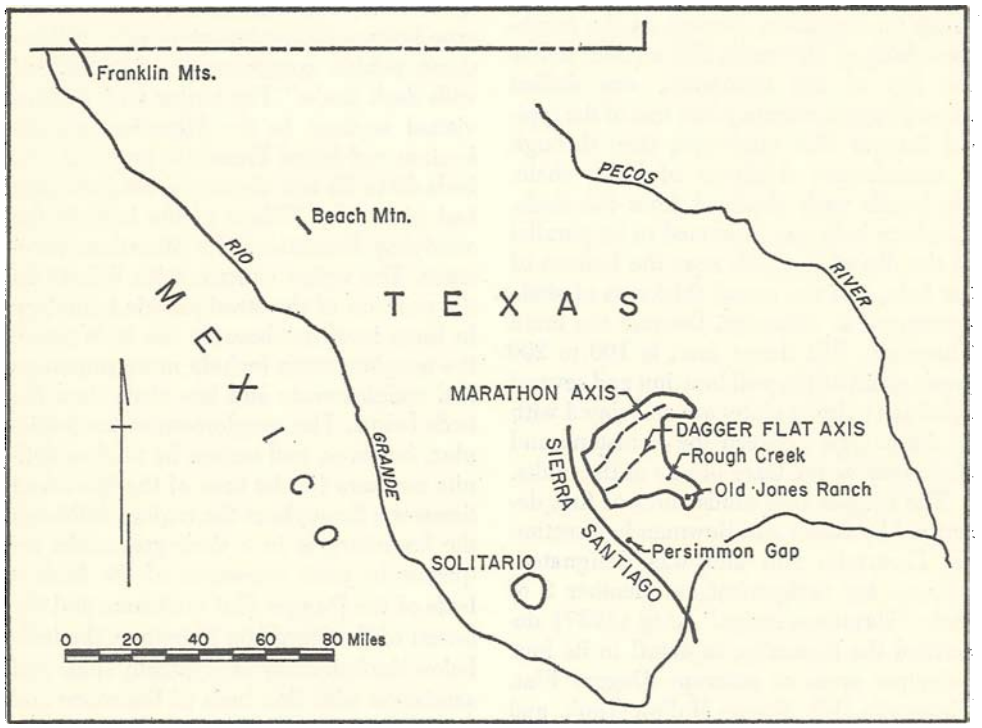

FIG. 1. Index map showing the Marathon region.

STRATIGRAPHY

CAMBRIAN SYSTEM

DAGGER FLAT SANDSTONE

Stratigraphy

The oldest rocks exposed in the Marathon region are the sandstones, shales, and limestones of Late Cambrian age named Dagger Flat sandstone by King (1931, p. 1064) from exposures in the Dagger Flat, 13 miles south of the town of Marathon. The greatest area of exposure of these rocks is on the south side of the Dagger Flat—northeast of the Buttrill ranch—where the massive sandstones form conspicuous ledges, but the formation is also exposed in the core of the Marathon anticlinorium. The base of the formation is not exposed, but the Turner No. 1 Combs, 16 miles south of Marathon, located on the northwest flank of Threemile Hill on beds below the top of the formation, was drilled through approximately 200 feet of the typical Dagger Flat sandstone, then through a considerable thickness of black shale. No fossils were obtained from the shale. The bore hole was presumed to be parallel to the dip of the beds near the bottom of the hole, and the actual thickness of shale penetrated is unknown. Because the main Threemile Hill thrust fault is 100 to 200 yards south of the well location and several subsidiary thrust plates are associated with it, the contact between the sandstone and shale may be the trace of one of the faults.

The Dagger Flat sandstone was first described by Baker and Bowman in a section on Threemile Hill and was designated, without age assignment, as Member 2 of their "Marathon series." King (1937) described the formation in detail in its four principal areas of outcrop—Dagger Flat, Threemile Hill, Woods Hollow Tank, and the Marathon anticlinorium. Wilson (1954a) restudied the formation and divided it into two members—a lower, Buttrill Ranch member, and an upper, Roberts Ranch, member.

The Buttrill Ranch member, which crops out in the Dagger Flat anticlinorium only, is best exposed about 5 miles northeast of the Buttrill ranch house and is typically a graywacke-shale sequence. Wilson (1954a) measured 270 feet of the member at its type locality. No fossils have yet been found in it.

The Roberts Ranch member was proposed by Wilson (1954a) for the higher beds of the Dagger Flat sandstone exposed along the crest of the Marathon anticlinorium, which is traversed by the road to Roberts ranch. It is principally black shale but does include beds of sandy, fine-grained dark gray limestone and brown graywacke. Its best exposures are 4 miles southwest of Marathon where a 225-foot section is exposed. Wilson (1954a, p. 251) designated the Roberts Ranch member in both its outcrop belts as "lying below prominent limestone pebble conglomerates interbedded with dark shale." The writer with Wilson visited sections in the Marathon anticlinorium and found Tremadoc graptolites in beds 60 to 75 feet above the conglomerate bed picked by Wilson as the base of the overlying formation, the Marathon limestone. The writer concurs with Wilson on the position of the stratigraphic boundary in these localities because the beds above the conglomerates include more limestone and conglomerate and less shale than the beds below. The conglomerates are lenticular, however, and cannot be used as definite markers for the base of the Marathon limestone throughout the region. Although the boundary is in a shale-graywacke sequence in most exposures of the highest beds of the Dagger Flat sandstone and the lowest of the Marathon limestone, the beds below the boundary are typically shale and sandstone with thin beds of limestone and limestone pebble conglomerate, whereas the beds above the boundary are typically limestone, shale, and conglomerate composed of slabs and chips of limestone with thin beds of subgraywacke. The position of the boundary between these two formations as used by both Wilson and the writer is

approximately 50 to 75 feet below that used by King in his maps of the Marathon region. This lower boundary was also used by H. M. Nielsen and members of the Gulf Oil Corporation field party who found it can readily be followed throughout the area. This boundary has been used for a number of years by personnel of summer field parties from several universities.

The writer considers that the lower position of the boundary is justified since it makes the typical shale-graywacke sequence of the Roberts Ranch member of the Dagger Flat sandstone a more homogeneous unit and more easily distinguished from the shale, flat limestone chip conglomerate, and thin-bedded, gray limestone sequence of the lower part of the Marathon limestone.

Fossils and Age

Most of the fossils found in the Dagger Flat sandstone have come from the Roberts Ranch member. Wilson (1954a, 1956) illustrated and discussed the fauna in detail. The only fossil collection from a measured section of the formation is from 225 feet below the top in a section 4 miles southwest of Marathon. Because he found *Geragnostus rudis, G. rudis* var. *holmi,* and an olenid tentatively identified as *Leptoplastus,* Wilson correlated these beds with Westergaard's (1947) zones 4 or 5 of the Upper Cambrian of Sweden. However, Wilson (oral communication), after finding additional and better preserved material in 1957, identified the Tremadoc trilobites *Shumardia, Pseudohystricurus, Bienbillia,* an olenid, and an apatokephaloid pygidium from these same beds. King (1937, p. 23) stated that Kirk and Resser considered fossils collected from the formation in the Dagger Flat anticlinorium to be Upper Cambrian. Thus, much of the Dagger Flat sandstone is probably Upper Cambrian, but at least the upper part of it is Tremadoc. As Wilson indicated (1954a, p. 266, fig. 4), the fauna of the Dagger Flat sandstone is of great interest because of its Atlantic Province affinities.

Ordovician System

General Features

The most complete succession of pre-Carboniferous strata of the Marathon uplift is exposed in the Marathon and Dagger Flat anticlinoria. The higher units in the succession also appear in subsidiary anticlines south of and between the two anticlinoria. South and southwest from the main uplifts, in the old Jones ranch, Persimmon Gap, and Rough Creek areas, Ordovician rocks are at the surface in the crests of faulted anticlines. Small remnants of Ordovician rocks are exposed along the front of the Sierra Santiago which is west and southwest of the Marathon uplift. Also, good exposures of Ordovician rocks are found in the Solitario, a small dome 50 miles to the south-southwest.

The Carboniferous and older strata were intensely folded and faulted so that, although exposures are excellent, complete stratigraphic sections of any formation are difficult to find. During the course of the present field work, twenty-two stratigraphic sections of Ordovician rocks were measured, but only one extends through more than one formation. The exposures on the southeast limb of the Marathon anticlinorium were found to be the least disturbed in the entire region.

The Ordovician section in the Marathon region is composed of relatively thick beds of shale and thinner beds of dark limestone and chert. Intercalated with these beds are lenses of conglomerate, graywacke, and exotic boulders. The most abundant fossils are graptolites, but inarticulate brachiopods and a few trilobites are also present. A similar environment existed during Ordovician time in the area of the present Ouachita Mountains (fig. 2), where the Ordovician section displays a shale, graywacke, and chert lithofacies and a graptolitic biofacies. Different lithotopes existed during Early Ordovician time to the northwest, north, and east of the Marathon region. Two hundred miles to the northwest, the El Paso limestone is nearly all dolomitic limestone characterized by a fauna of orthoid brachiopods,

cephalopods, trilobites, and sponges. The limestone-dolomite sequence of the Ellenburger has been found in the subsurface 12 miles north of Marathon and is exposed in the Llano region. The Ellenburger has a nautiloid, gastropod, and brachiopod biofacies. A thick section of limestones and quartzose sandstones of Ordovician age is exposed in the Arbuckle Mountains in Oklahoma, bearing a brachiopod, trilobite, nautiloid biofacies.

The Ordovician rocks in the Marathon region consist largely of limestone and shale. The rock succession is, therefore, of a different lithofacies from the surrounding region, and the fauna is of a different biofacies. Because of this facies difference, correlation of the Ordovician rocks in the Marathon area with Ordovician rocks to the northwest, north, and northeast is difficult. The Ordovician system in the Marathon region was divided by King (1931) into five formations; in ascending order these are the Marathon limestone, the Alsate shale, the Fort Peña formation, the Woods Hollow shale, and the Maravillas chert.

Graptolites are plentiful throughout the section, occurring in the shales, in all kinds of limestone, impressed on chert and, even rarely, in the quartz sandstones. The majority of the specimens, including the best preserved, were obtained from the limestones.

With the exception of the Alsate shale, one or more zones have been recognized in each formation, giving a total of fifteen within the Ordovician system. At the outset of any discussion of paleontologic zones, the meaning of the term "zone" should be made clear because "zone" has several meanings—even in biostratigraphy. A good summary of the history of the use of the word "zone" can be found in Teichert (1950). Although Oppel (1856–1858) used "zone" to mean a belt of strata de-

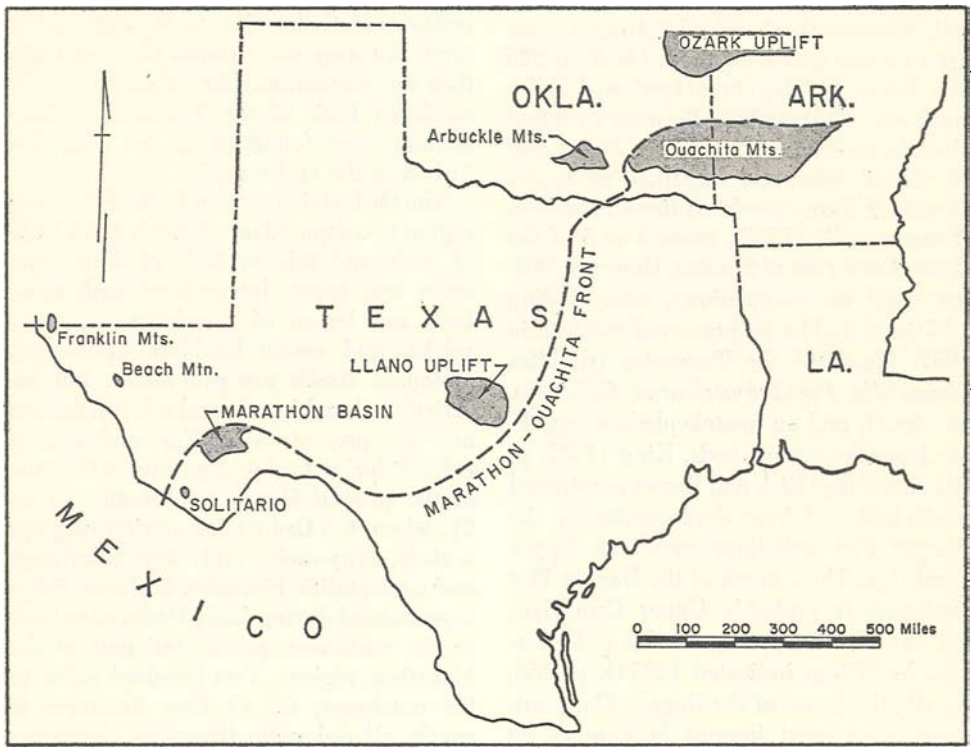

FIG. 2. Map of south-central United States showing areas of Ordovician exposures.

limited by paleontologic criteria, and this usage of the word "zone" has been widely adopted, others (Wedekind, 1916; Fiege, 1951) maintain that a "zone" is a biochron, or the life span of a species whose progenitor and descendant are known. Used thus, "zone" is a time term rather than a time-rock term.

In the present paper, the word "zone" is used to mean a thickness of rock containing an assemblage of species which does not occur in exactly the same combination in beds above or below. Generally one or more species are restricted to a particular zone. Some species occurring in a given zone range into it from the zone below, while other species range through the zone into the zone above. Still other species range through several zones. The zone is thus a stratigraphic unit, occurring in more than one locality, characterized by an association of fossils, one of which has been chosen as the name-giving species or genus. Each zone has not only regional but also interregional application. Thus the zones presented herein are not merely subdivisions of the local section but are time-stratigraphic units of interregional extent.

Figure 3 indicates in a general way the changes in the types of graptolites with the passage of time which give rise to zonal divisions. Successively higher zones are marked by the appearance in abundance of a new form or forms. The concept that the entry of new forms may be used to indicate the beginning of a new zone is consistent with the practice of British and Austrialian graptolite workers.

GRAPTOLITE ZONES

Fifteen graptolite zones have been delimited within the Ordovician section in the Marathon region. These are listed here in ascending order and will be discussed in more detail as they appear in successive formations. The names of the zones and outline figures of the characteristic forms of each are given in figure 3.

Zone 1, *Anisograptus,* is characterized by species of *Anisograptus* and *Clonograptus.* The fauna from this zone is sparse in the Marathon region, but in eastern North America it includes *Staurograptus, Radiograptus,* and several species of *Dictyonema.*

Zone 2, *Adelograptus-Clonograptus.* In this zone, the multiramous dichograptids reach their zenith. Several species of *Clonograptus* and *Adelograptus* are found only in this zone, and representatives of the genera *Anisograptus* and *Triograptus* range into it.

Zone 3, *Tetragraptus approximatus,* is marked by the initial phase of the prolific speciation within the genera *Didymograptus* and *Tetragraptus.* Several species of *Tetragraptus* are present, of which the most diagnostic is *T. approximatus.*

Zone 4, *Tetragraptus fruticosus* (four-branched form), is characterized by the appearance of that distinctive species. Many species of *Tetragraptus* and *Didymograptus are* present, and the last representatives of the genera *Adelograptus* and *Clonograptus* occur here.

Zone 5, *Tetragraptus fruticosus* (three and four-branched), is marked by appearance of the three-branched form with the four-branched form of this familiar species. The number of species of the Didymograpti and the Tetragrapti reach a maximum in this zone.

Zone 6, *Didymograptus protobifidus,* is marked by the appearance of the first dependent didymograptid, *D. protobifidus.* Both the four-branched and three-branched forms of *T. fruticosus* are prominent here.

Zone 7, *Didymograptus bifidus,* is characterized by the two dependent didymograptids *D. artus* and *D. bifidus.* The numbers of species of both the tetragraptids and didymograptids are much fewer in this zone than in the preceding four zones, and the first of the Isograpti appear here.

Zone 8, *Isograptus caduceus*, is denoted by the development of the large varieties of *I. caduceus* and by the genera *Oncograptus* and *Cardiograptus*. The first graptolites with a biserial scandent rhabdosome appear here.

Zone 9, *Hallograptus etheridgei*, is marked by the appearance of several types of biserial scandent rhabdosome in the genera *Glossograptus*, *Glyptograptus*, *Hallograptus*, and *Climacograptus*. The multiramous dichograptids and the tetragraptids appear for the last time.

Zone 10, *Glyptograptus* cf. *G. teretiusculus*, is characterized by the widespread development of *G.* cf. *G. teretiusculus* and *Amplexograptus confertus*. *Phyllograptus* makes its last appearance here.

Zone 11, *Nemagraptus gracilis*, is marked by the incursion of the genera *Nemagraptus*, *Dicellograptus*, *Dicranograptus*, and *Leptograptus*, each represented by several species. The biserial scandent rhabdosome is common in this zone, but species of this type are overshadowed by the other elements.

Zone 12, *Climacograptus bicornis*, is characterized by large diplograptids and by *C. bicornis* with stout spines at the proximal end. The last didymograptids are found in this zone.

Zone 13, *Orthograptus truncatus* var. *intermedius*, is marked by a "burst" of the large Orthograpti. The presence of *Orthograptus calcaratus* var. *incisus* and *O. quadrimucronatus* var. *angustus*, with or without *O. truncatus* var. *intermedius*, clearly indicates the zone.

Zone 14, *Orthograptus quadrimucronatus*, is characterized by the widespread development of that distinctive species. The presence of large Orthograpti of the species *Orthograptus calcaratus* with *Climacograptus tubuliferus* are also indicative of the zone.

Zone 15, *Dicellograptus complanatus* var. *ornatus*, is typified by the assemblage of *Climacograptus missisippiensis*, *Diplograptus crassitestus*, and *Orthograptus truncatus* var. *socialis* with the distinctive *Dicellograptus complanatus* and its varieties. Also, a form like a typical Silurian climacograptid appears in this zone.

MARATHON LIMESTONE

General Features

All the Ordovician rocks of the Marathon basin, except the Maravillas chert, were embraced in the "Marathon series" of Baker and Bowman (1917). They recognized as subdivisions, five members which were numbered but not named, and within this framework Ulrich recognized four faunal zones. In 1931, King abandoned the term Marathon series, subdivided these rocks into four formations, and restricted the name Marathon limestone to the lowest of these units. The relation of the two schemes is shown in table 1.

Only the upper part of the Marathon limestone is exposed at the type locality in the streets and vacant lots of the town of Marathon. Good exposures of the entire formation are easily accessible on the southeast side of the road to Roberts ranch. A complete section of the formation was measured on the east side of a gap between ridges of the Marathon limestone about 2.7 miles down the road toward Roberts ranch from a cairn built where the road turns southwest past the Alsate Creek exposures. The cairn bears S. 25° W. from Iron Mountain and due south from the peak of Cathedral Mountain.

The Marathon limestone, as measured in the Marathon anticlinorium, is between 840 and 890 feet thick. There are no complete sections in the Dagger Flat anticlinorium nor in any of the more southerly exposures. The formation is divisible into

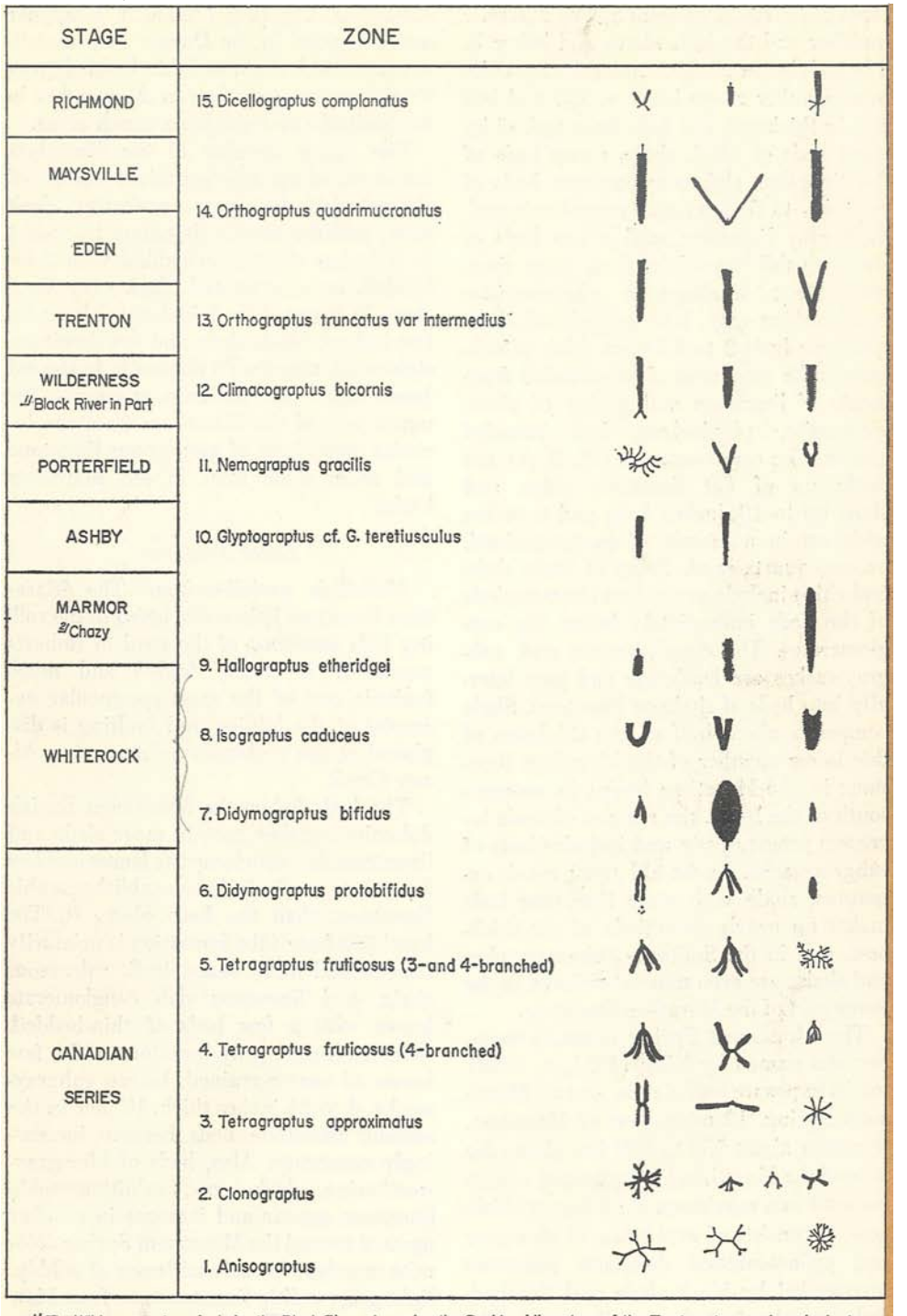

FIG. 3. Diagram showing graptolite zones with sketches of the principal species in each.

three parts, the Monument Spring dolomite member and the beds above and below it. The beds below the Monument Spring dolomite member range between 530 and 600 feet in thickness and are characterized by thick beds of black shale, many beds of flat limestone slab conglomerate, beds of medium- to fine-grained, cross-laminated, dark gray limestone, and a few beds of slabby, sublithographic, dark gray limestone that weathers a characteristic medium blue gray. Interbedded with these are some beds 3 to 6 inches thick of subgraywacke composed of subrounded fragments of limestone and grains of chert, glauconite, plagioclase, and rounded quartz. The conglomerates (Pl. 2, A) are made up of flat limestone chips and slabs up to 18 inches long and 6 inches wide set in a matrix of coarse-grained, brown, quartz sand. Some of these slabs and chips include graptolites characteristic of the beds immediately below the conglomerates. The conglomerates and subgraywackes are lenticular and pass laterally into beds of shale or limestone. Shale comprises about half of the thickness of this lower member of the Marathon limestone in the Marathon basin; in outcrops south of the basin, the amount of shale increases progressively and includes beds of subgraywacke. In the old Jones ranch exposures, shale with some limestone beds makes up nearly two-thirds of the thickness, and in the Solitario, subgraywackes and shales are even more prominent in the lower part of the Marathon limestone.

The Monument Spring dolomite member was named by King (1931, p. 1068) for its exposure half a mile west of Monument Spring, 12 miles west of Marathon. It occurs about 550 to 600 feet above the base of the Marathon limestone and ranges from 40 to a maximum of 90 feet in thickness. It consists of oval lenses of blue-gray and yellow-mottled dolomitic limestone surrounded by black shale and thin-bedded, cross-laminated, gray limestone. The lenses of dolomitic limestone are present throughout much of the Marathon anticlinorium, but they gradually disappear southeastward in the Dagger Flat anticlinorium. Black shale and thin-bedded, gray limestone are equivalent to the member in the Solitario and old Jones ranch areas.

The upper member of the Marathon limestone, about 250 feet thick, consists of characteristic blue-gray weathering, dark gray, sublithographic limestone in beds 4 to 8 inches thick interbedded with thin-bedded, cross-laminated, dark gray limestone in layers 4 to 6 inches thick and a few beds of black shale and flat limestone slab conglomerate. To the south, in the old Jones ranch and Solitario exposures, the upper part of the Marathon limestone includes many beds of arenaceous limestone and more shale than in the Marathon basin.

Local Features

Marathon anticlinorium.—The Marathon limestone is best displayed in the rolling hills southeast of the road to Roberts ranch. It is closely folded and much faulted; one of the most spectacular examples of the folding and faulting is displayed at the well-known outcrops on Alsate Creek.

The beds below the Monument Spring dolomite member contain more shale and limestone slab conglomerate lenses and less limestone, particularly less sublithographic limestone, than the beds above it. The basal 300 feet of the formation is primarily interbedded black shale, buff, calcareous shale, and limestone slab conglomerate lenses with a few beds of thin-bedded, cross-laminated, gray limestone and a few lenses of coarse-grained, brown subgraywacke, 4 to 24 inches thick. Higher in the section, limestone beds become increasingly numerous. Also, beds of blue-gray-weathering, dark gray, sublithographic limestone appear and increase in number upward toward the Monument Spring dolomite member. Occasional lenses of pebbly, light gray, oolitic limestone are found low in the section. They have a fauna of trilobites and molluscs in contrast to the graptolite fauna in the surrounding rocks.

A

Limestone chip conglomerate lens in the Marathon limestone.
(Photograph by D. B. Clarke)

B

Alsate shale at its type locality on Alsate Creek. The hammer is lying on a conglomerate lens at the top of the Marathon limestone.

A

Anticlinal valley in the Woods Hollow shale on the crest of Simpson Springs Mountain.

B

Typical exposure of the Maravillas chert. Black chert is interbedded with gray-weathering limestone.

(Photograph by D. B. Clarke)

Table 1. Relation of nomenclature applied to Cambrian and Ordovician rocks in the Marathon region. After King (1931, p. 1066).

System	Baker and Bowman (1917)		Ulrich (*in* Baker and Bowman, 1917)	King (1931)
Ordovician	Maravillas chert		Zones 5 and 6	Maravillas chert
	Marathon series	Member 5 Member 4 Member 1 and Brewster formation	Zone 4 Zones 1 and 2 in boulders	Woods Hollow shale
		Not seen		Fort Peña formation
		Not seen		Alsate shale
		Member 3 is a small part of the Marathon limestone	Zone 3	Marathon limestone (a) upper member (b) Monument Spring dolomite (c) lower member
Cambrian		Member 2		Dagger Flat sandstone

The conglomerate lenses are similar in appearance above and below the Monument Spring dolomite member. Locally, the lenses reach 10 to 15 inches in thickness; they extend from a few feet to several yards along strike. The slabs within the conglomerate consist of thin-bedded, cross-laminated, dark gray limestone and blue-gray-weathering, sublithographic limestone, are elongate with maximum dimensions of 18 inches in length and 6 inches in width, and lie subparallel to one another in a matrix of coarse brown sandstone containing rounded chert pebbles. The subgraywacke lenses also are similar above and below the Monument Spring dolomite member. They are composed of small fragments of shale, limestone, other arenites, rounded quartz grains, plagioclase, biotite, glauconite, chert, and sericite with calcite and phosphate cement. No graded bedding was seen. Thin, buff, argillaceous limestone layers found sporadically throughout the section have well-developed mud cracks. The weathered surfaces of some of the limestone beds are thickly strewn with separated hexactinellid sponge spicules, whereas other limestone bedding surfaces show minute channel markings and are overlain by one-eighth to one-quarter-inch layers of sandstone. Commonly such sandstone layers are crowded with worn, broken shells of inarticulate brachiopods.

The Monument Spring dolomite member is 94 feet thick near Alsate Creek and ranges from 40 to 60 feet in thickness in the northern part of the Marathon anticlinorium but thins southward, being only 25 feet thick at Monument Spring, the type locality. The member consists of oval lenses of dense, gray, dolomitic limestone aligned subparallel to each other separated by shale and thin-bedded, cross-laminated, gray limestone. The weathered surface of the dolomitic limestone has a blue-gray and yellow-mottled appearance, and where replacement by silica has occurred it weathers to a characteristic orange-brown color. The individual lenses range in size from 10 feet long and 5 feet wide to 50 feet long and 25 feet wide. In some places the lenses are separated from one another by several feet of shale or thin-bedded limestone, but in other places, several lenses lie close together and overlap each other. Fossil fragments are common in places in the dolomitic limestone—there are vague algal structures, sponges of the type of *Archeoscyphia*, orthoid brachiopods, and cephalopods. The oval masses that characterize the Monument Spring member were probably patch reefs constructed principally of algae and sponges. Although small blocks of the dolomitic limestone occur higher in the section, it is predominantly at one horizon, and that horizon lies entirely within one graptolite zone.

In the beds above the Monument Spring dolomite member, blue-gray-weathering sublithographic limestone in layers 4 to 8 inches thick predominates. Of nearly equal importance are layers of medium- to fine-grained, thin-bedded, cross-laminated, dark gray limestone, 3 to 6 inches thick, exhibiting a few slump structures. The slump structures do not extend laterally for more than 10 feet in any one bed. Beds of black shale, buff argillaceous limestone, and buff to orange-weathering black limestone and lenses of flat limestone slab conglomerate and subgraywacke are subordinate rock units in the upper part of the formation. Two layers of black chert, each about 1 inch thick, occur near the top of the formation in the northern part of the southeast limb of the Marathon anticlinorium. A few blocks of characteristic Monument Spring dolomitic limestone are found in this upper member and are commonly associated with a conglomerate or sandstone lens. Most of the blocks are 6 to 18 inches long and in some places they extend discontinuously for as much as 20 feet along the strike.

Dagger Flat anticlinorium.—The Marathon limestone is so intensely folded and faulted in its exposures in the Dagger Flat anticlinorium that no continuous section can be measured on the northwest limb and only a partial section of the lower part of the formation can be measured on the southeast limb. The rocks comprising the

Marathon limestone here exhibit the same lithologic relations and details as they do in the Marathon anticlinorium except that the Monument Spring member includes more shale and thin-bedded, gray limestone and less gray, dolomitic limestone. No determination of thickness for the formation is possible in this anticlinorium.

On the northwest limb, younger beds of the Marathon limestone appear in the troughs of synclines and older beds appear in the crests of adjoining anticlines. The section is repeated many times with progressively older beds appearing in the subsidiary anticlines and synclines going from the limb toward the center of the anticlinorium. The Threemile Hill thrust fault can be traced eastward several miles from the base of Threemile Hill along the southeast limb of the Dagger Flat anticlinorium. A collection of graptolites characteristic of the upper part of the Marathon limestone was obtained from a shale outcrop at the base of Threemile Hill. At a locality 3 miles northeast of Threemile Hill and 2 miles northeast of Buttrill ranch, graptolite collections were made from a measured section. Zonal determination of the graptolites indicates that the uppermost 30 feet of the Marathon limestone rests on the basal 340 feet. Therefore, most of the upper part of the formation, the Monument Spring member, and almost half of the lower part of the formation are missing. Thus King's observation (1937, p. 29) that the Marathon limestone thins to 350 feet on the southeast limb of the Dagger Flat anticlinorium has a structural and not a stratigraphic explanation. Ten miles southwest of Peña Blanca Spring, six collections of graptolites were made in a traverse of 1,200 feet across the strike of the beds. Each collection belonged to the same graptolite zone, thus demonstrating tight isoclinal folding.

Old Jones ranch and Solitario areas.— Completely folded and faulted Ordovician rocks crop out under the Cretaceous rim in an arroyo which is about 2 miles S. 20° E. from the present Slaughter ranch headquarters (formerly old Jones ranch). These are the most complete and extensive outcrops of the older Paleozoic rocks southeast of the Marathon uplift. Wilson (1954b) described the exposures in this area and in the Solitario. However, collections of graptolites made by the writer have made possible a more detailed understanding of the Ordovician stratigraphy in these regions.

In both areas the lower part of the Marathon limestone includes calcareous subgraywacke interbedded with the typical shale, flat limestone slab conglomerate, and limestone sequence. The dolomitic limestone of the Monument Spring member is not present in either area, and the member is equivalent to interbedded black shale and thin-bedded, cross-laminated, gray limestone. In these southern exposures the upper part of the formation has more shale and more thin-bedded, cross-laminated, gray limestone in relation to blue-gray-weathering, dark gray, sublithographic limestone than in the main uplift. Thick beds of subgraywacke and brown-weathering arenaceous limestone occur in the upper part of the formation in both areas; and in the Solitario, several beds of chert are included in the upper part of the formation. In summary, the Marathon limestone is more clastic in the Solitario and old Jones ranch areas, with shale and subgraywacke the predominant rock types at the top and the base of the formation.

Fossils and Age

The fauna of the Marathon limestone includes two distinct facies. The Monument Spring dolomite has a fauna of sponges, brachiopods, and nautiloids, and the rest of the formation bears graptolites, inarticulate brachiopods, and trilobites. Except in the Monument Spring member, graptolites dominate. The best-preserved specimens occur in limestones, most commonly those of sublithographic texture. In all, seven graptolite zones have been delineated in the Marathon limestone, two below the Monument Spring dolomite and four above it. The complete fauna is given in the following check list (p. 16).

The lowest zone, that of *Anisograptus*,

Zonal distribution of species in the Marathon limestone

SPECIES	ZONE[2] 1	2	3	4	5	6	7
Adelograptus hunnebergensis (Moberg)?		x					
Adelograptus pusillus (Ruedemann)				x			
Adelograptus simplex (Tornquist)		x					
Adelograptus victoriae (T. S. Hall)		x					
Anisograptus dissolutus Berry, n.sp.	x						
Bryograptus crassus (Harris and Thomas)?		x					
Clonograptus flexilis (Hall)		x	x	x			
Clonograptus persistens Harris and Thomas		x					
Clonograptus rigidus (Hall)		x	x				
Clonograptus cf. C. tenellus (Linnarson)	x						
Clonograptus tenellus var. callavei (Lapworth)		x					
Dichograptus octobrachiatus (Hall)			x	x	x	x	
Dictyonema dumosus Berry, n.sp.				x			
Didymograptus artus Elles and Wood							x
Didymograptus bifidus (Hall)							x
Didymograptus denticulatus Berry, n.sp.							x
Didymograptus ellesae Ruedemann				x			
Didymograptus extensus (Hall)			x	x	x	x	
Didymograptus leptograptoides Monsen						x	
Didymograptus nicholsoni Lapworth				x	x	x	
Didymograptus nicholsoni var. planus Elles and Wood				x	x		
Didymograptus nitidus (Hall)			x	x	x	x	
Didymograptus novus Berry, n.sp.		x					
Didymograptus patulus (Hall)				x	x	x	
Didymograptus protobifidus Elles						x	
Didymograptus protoindentus Monsen							x
Didymograptus similis (Hall)					x	x	x
Goniograptus perflexilis Ruedemann							x
Gonigraptus thureaui (McCoy)						x	
Isograptus caduceus var. lunata Harris							x
Phyllograptus angustifolius Hall					x	x	
Phyllograptus anna Hall					x	x	x
Phyllograptus anna mut. longus Ruedemann						x	
Phyllograptus ilicifolius Hall				x	x	x	x
Phyllograptus typus Hall						x	x
Ptilograptus plumosus Hall				x			
Tetragraptus acclinans Keble				x			
Tetragraptus amii Lapworth				x	x	x	
Tetragraptus approximatus (Nicholson)			x				
Tetragraptus bigsbyi (Hall)			x	x	x	x	x
Tetragraptus decipiens T. S. Hall		x					
Tetragraptus decipiens var. bipatens Keble and Harris						x	
Tetragraptus fruticosus (4-branched form) (Hall)				x	x	x	
Tetragraptus fruticosus (3-branched form) (Hall)					x	x	
Tetragraptus pendens Elles				x			
Tetragraptus pygmaeus Ruedemann					x	x	
Tetragraptus quadribrachiatus (Hall)			x	x	x	x	x
Tetragraptus reclinatus Elles and Wood						x	
Tetragraptus serra (Brongniart)					x	x	x
Tetragraptus taraxacum Ruedemann			x		x	x	
Triograptus cf. T. otagonensis Benson and Keble	x	x					
Trochograptus lapworthi Ruedemann				x			
Parabolinopsis mariana Hoek	x						
Beltella latifrons Wilson		x					
Bellefontia sp.	x						
Kayseraspis sp.		x					
Lloydia sp.	x						
Protopliomerops sp.					x		
New genus related to Benthamaspis				x			
Symphysurina cf. S. woosteri Ulrich		x					
Ophileta sp.		x					
Tostonia sp.		x					
Endoceras sp.			x				
Pachendoceras sp.		x					
Shumardoceras sp.			x				
Archeoscyphia aff. A. annulatum Cullison			x				
Finkelnburgia sp.		x					

[2] Explanation of the various zones in this and similar lists is given in figure 3 and on pp. 7–9.

has a rather sparse assemblage of species, seemingly because the basal beds of the formation are more clastic. *Anisograptus* is the typical genus here but is usually accompanied by *Clonograptus* cf. *C. tenellus* and *Triograptus*. Several pygidia and cephalons of *Bellefontia* sp. and *Lloydia* sp. were collected from the upper part of this zone.

The zone is well developed at localities 6, 29, 118, and 119 (see Appendix). Near the contact between this zone and the next above, the faunas intermingle so that a precise boundary is difficult to locate, but the zone is approximately 200 feet thick. Wilson (1954a) recorded *Parabolinopsis mariana* from 163 feet above its base in measured section I (Appendix).

The second zone of the Marathon limestone is characterized by several species each of the genera *Clonograptus* and *Adelograptus*. Early representatives of the genera *Tetragraptus* and *Didymograptus* are found here also. Typical zonal assemblages were obtained in collections 2, 11, 12, 33, 37, 74, and 84. Wilson (1956, p. 1348) recorded *Kayseraspis, Symphysurina* cf. *S. woosteri, Beltella latifrons, Tostonia, Ophileta,* and *Finkelnburgia* from the locality of collection 34. The writer collected *Ophileta* and a *Pachendoceras* from the same locality. Zone 2 ranges from 330 to 400 feet thick.

Zone 3 and the succeeding four zones are characterized by a burst in speciation within the genera *Didymograptus* and *Tetragraptus*. Three species of these genera range through all five zones, but the majority of the species are confined to only two or three zones. The appearance of certain combinations of species of *Tetragraptus* and *Didymograptus* with species of other genera are diagnostic enough so that five zones have been recognized in the upper 290 to 340 feet of the Marathon limestone.

The third zone is characterized by the appearance of several species of *Didymograptus* and *Tetragraptus* and by the persistence of two species of *Clonograptus* from the zone below. The most diagnostic species is *Tetragraptus approximatus*, and the base of the zone is picked by its first appearance. Good collections of the typical species of the zone were obtained from localities 76, 77, 120, and 130.

In the Marathon anticlinorium, the typical zonal assemblages collected from shales and limestones interbedded with the Monument Spring dolomite indicate that the member lies completely within zone 3. Good collections of the typical zone assemblage have been made in the old Jones ranch and Solitario areas, where the Monument Spring member is not present.

For the most part, the fauna of the Monument Spring dolomite member is of a different biofacies from that of the other two members of the Marathon limestone. It contains sponges, orthoid brachiopods, cephalopods, gastropods, and some algal masses. Kirk (1934, p. 451) indicated that the characteristic sponge-cephalopod fauna of the lower part of the El Paso limestone is well developed in the Monument Spring member of the Marathon limestone. He stated that: "*Calathium, Piloceras,* and *Colpoceras* are represented by identical species with those in the lower El Paso." King (1937, p. 30) reported masses of *Cryptozoon, Calathium* cf. *C. formosum* and two other species of sponges, and undetermined species of orthoid brachiopods and gastropods from the Monument Spring member. Cloud and Barnes (1948, p. 64–66) obtained *Calathium*, cystoid plates and columnals, *Diaphelasma* sp., "*Orthis*" sp., *Allopiloceras* cf. *A. coarctum*, fragments of other piloceratid cephalopods, and a trocholitid cephalopod from the member. The writer has collected *Shumardoceras, Endoceras,* and *Archeoscyphia* aff. *A. annulatum* Cullison from the Monument Spring member as well as unidentified fragments of orthoid brachiopods, cephalopods, and sponges. The fauna is preserved as silicified fragments on the surface of the dolomitic limestone and is thus hard to collect. Sponge remains are relatively abundant and can be found in many of the exposures but other fossils are rare.

Zone 4 is characterized by the appear-

ance of additional species of the genera *Tetragraptus* and *Didymograptus* and by the last appearance of *Clonograptus* and *Adelograptus*. The most widespread and typical species of this zone is the four-branched form of *Tetragraptus fruticosus*. The typical zonal assemblage was found best developed in collections 69 and 71. The lower boundary of the zone is defined by the first appearance of the four-branched form of *Tetragraptus fruticosus* while the upper boundary is placed at the first appearance of the three-branched form of this species. Zone 4 is about 30 feet thick.

The fifth zone is characterized by the appearance together of the three- and four-branched forms of *Tetragraptus fruticosus*. Also, the Phyllograpti are represented by three species, two of which appear for the first time. Two specimens were found of a trilobite which is similar to a species of the genus *Protopliomerops* figured by Ross (1951, pl. 31). Good collections were obtained in the Alsate Creek section (measured section XVIII, collections 26 and 27) and at localities 66, 90, and 91. The zone is about 40 feet thick.

Zone 6 is marked by the appearance of the dependent didymograptid *Didymograptus protobifidus* with the three-branched form of *Tetragraptus fruticosus*. Several species of the Tetragrapti and of the Didymograpti are seen for the last time in this zone for the burst of speciation in these two genera is over. The dependent type of *Didymograptus* makes its first appearance here. Typical zonal assemblages were found in the Alsate Creek section (measured section XVIII, collections 22, 23, 24F, and 25), and in fossil collections 40, 52, 63, and 64. The zone, the thickest of those above the Monument Spring member, is about 140 feet thick.

The seventh zone is delimited by the well-known and widespread species *Didymograptus bifidus* and *Didymograptus artus*. Other species of dependent Didymograpti are present, while the extensiform Didymograpti are now represented by fewer species than before. *Phyllograptus typus* is common, and the first of the Isograpti appear here. The minute form *I. caduceus* var. *lunata* is infrequently found with the typical zonal assemblage. Good collections from this zone were secured at Alsate Creek (measured section XVIII, collections 19, 20, and 24A) and at localities 47, 67, and 70. The zone is 30 feet thick.

The Alsate Creek exposures afforded the best collecting in the entire area. The section yielded graptolites in nearly every inch of rock from the Monument Spring member to the Alsate shale, permitting very detailed zonal determinations for the beds above the Monument Spring member. Turner (1940) described a trilobite (*Seleneceme bakeri* (Turner)), from the Marathon limestone below the Alsate shale at the Alsate Creek section; it probably came from either zone 6 or zone 7. Kindle (1942) described a similar trilobite (*Seleneceme evansi* (Kindle)) from Canada where it was collected from beds containing *Didymograptus bifidus*, suggesting an affinity with zone 7 of the Marathon sequence.

Shelly fossils are not common enough in the Marathon limestone to permit detailed correlation between the graptolite zones and sequences where the shelly fossils are dominant. The lower part of the Marathon limestone, however, has yielded a few diagnostic trilobites. Wilson (1954a) collected the Tremadoc species *Parabolinopsis mariana* from beds that are in graptolite zone 1, and the writer collected *Bellefontia* and *Lloydia* from the same zone. The *Bellefontia* indicates a possible correlation with the Gasconade dolomite of the standard Lower Ordovician section for North America. The assemblage of *Pachendoceras*, *Symphysurina* cf. *S. woosteri*, *Ophileta*, and *Finkelnburgia* from the lower part of graptolite zone 2 also correlates with the Gasconade dolomite. Graptolite zone 1 and at least part of zone 2 are equivalent to the Gasconade dolomite. Further, the presence of *Bellefontia* and *Symphysurina* cf. *S. woosteri* indicates a correlation of zone 1 and a part of zone 2 with Ross' zones A and

B of the Garden City limestone in northeastern Utah.

The fauna of the Monument Spring member, although of a shelly biofacies, is poorly preserved so that accurate correlation of it is difficult. Kirk (1934, p. 451) correlated it with the lower part of the El Paso limestone of the Franklin Mountains. Cloud and Barnes (1948) were only able to assign post-Tanyard age to the assemblage which they collected from the member. The evidence from the cephalopods indicates a Middle or Late Canadian age. The genus *Piloceras* is restricted to the Canadian as is the genus *Allopiloceras*. All known species of the genus *Shumardoceras* have come from the upper part of the Jefferson City group or equivalent beds. The presence of sponges similar to *Archeoscyphia annulatum* indicates a possible correlation with the Rich Fountain formation. Further, the writer compared sponges from the Monument Spring member with sponges from the middle part of the Kindblade limestone in the Arbuckle Mountains and is of the opinion that similar forms are present in both areas. The Kindblade limestone has been correlated with the Jefferson City group. In summary, zone 3, which includes the Monument Spring member, is considered a correlative of the Jefferson City group.

There are no shelly fossils of value in correlation in the Marathon limestone above the Monument Spring member. However, *Didymograptus protobifidus*, which is characteristic of zone 6, has been recognized by Decker in the Smithville limestone of the standard Lower Ordovician section and in the West Spring Creek formation in the Arbuckle Mountains. *Didymograptus artus* and *D. bifidus*, the diagnostic elements of zone 7, are recorded from the Joins formation in the same area (Ruedemann, 1947, p. 88). Cooper (1956, p. 119) assigned the Joins formation to the early Middle Ordovician, Whiterock stage. *Didymograptus bifidus*, the characteristic species of zone 7, is listed by Ross (1951, p. 27) in zone M, which is present in the Swan Peak formation in northeastern Utah. Cooper (1956, p. 130), because of the presence of *Anomalorthis* in the fauna, placed the Swan Peak formation in the Whiterock stage. Ruedemann (1947, p. 327) reported *D. bifidus* from the Black Rock limestone of the standard section for the Lower Ordovician. Graptolite zones 4 and 5 lie between two zones which have been correlated with units in the standard section for the Lower Ordovician; thus these zones are possible correlatives of the Cotter and Powell formations in the Ozark region.

Tremadoc fossils have been found 25 feet above the contact of the Marathon limestone with the Dagger Flat sandstone and 225 feet below the contact. If the Tremadoc belongs in the Ordovician, as is now commonly considered, then, with the exception of the uppermost graptolite zone, the Marathon limestone is Early Ordovician. The top 30 feet is Whiterock (early Middle Ordovician) age.

ALSATE SHALE

General Features

King (1931, p. 1069) named the Alsate shale for Alsate Creek (Pl. 2, B) exposed in the bank of the creek, 2½ miles west of the Picnic Grounds, 5 miles south-southwest of Marathon (Pl. 1). It is a black shale that forms a distinct break between the characteristic blue-gray-weathering Marathon limestone and the tan-weathering limestones and calcareous sandstones of the Fort Peña formation; in most places, it occupies a covered interval between outcrops of these formations.

Local Features

Marathon anticlinorium.—In the Alsate Creek exposure, a conglomerate underlies the black shale and was included in the Alsate shale by King. However, the conglomerate is merely a lens which can be traced into the blue-gray-weathering, dark gray, sublithographic limestone at the top of the Marathon limestone and it thus belongs there and not in the Alsate shale.

In this anticlinorium, the Alsate shale is well indurated, greenish weathering, and

breaks into small rhomboid chips. It is about 100 feet thick in Alsate Creek and in exposures on the ridge east of the road to Roberts ranch but thins to 85 feet 3 miles to the southwest.

Dagger Flat anticlinorium.—The Alsate shale is much thinner and commonly occupies a covered interval in this area. It is a greenish-weathering black shale. The granular limestone layers containing *Oncograptus*, which King (1937, p. 31) described as a part of the formation, belong to the overlying Fort Peña formation.

Fossils and Age

The formation contains a sparse graptolite fauna. The best collections came from the outcrop in Alsate Creek (measured section XVIII, collection 18) where *Isograptus caduceus* var. *lunata*, *Phyllograptus typus*, *Tetragraptus amii*, *Didymograptus affinis*, and *Didymograptus mendicus* were collected. *Isograptus caduceus* var. *lunata* was also collected from several other exposures of the formation and is the most common fossil in it.

This fauna is transitional between that of the *Didymograptus bifidus* zone and that of the *Isograptus caduceus* zone, because it has species which are characteristic of both. However, the writer considers it to be more closely related to that of the *I. caduceus* zone and it therefore is included in that zone. The formation falls within the Whiterock stage of Cooper as does the rest of the *I. caduceus* zone.

RODRIQUEZ TANK SANDSTONE

In the Solitario and old Jones ranch areas the black Alsate shale is not present between the characteristic limestones of the Marathon limestone and the Fort Peña formation; in its place is a white to buff quartzose sandstone that ranges from 20 to 50 feet in thickness. The sandstone is composed of well-rounded quartz grains. Graptolites characteristic of the uppermost part of the Marathon limestone were collected 3 inches below the sandstone, and graptolites diagnostic of the basal beds of the Fort Peña formation were collected 1 inch above the sandstone in both areas. Thus the exact stratigraphic position of the sandstone has been determined from paleontologic evidence.

Although the sandstone is well exposed outlining a recumbent anticline under the Cretaceous rim in the old Jones ranch area, that exposure is not easily accessible. Therefore, the writer designates the northern part of the Solitario as the type locality and names the formation the Rodriquez Tank sandstone for its outcrops near the Rodriquez Tank shown on the map of the Solitario by Wilson (1954b, p. 2464). A measured section that shows the stratigraphic relation of the sandstone to the underlying and overlying formations is not given because of the structural complexity of the northern part of the Solitario. Sandstone lenses which locally appear similar to the Rodriquez Tank sandstone are present in the upper part of the Marathon limestone in both the Solitario and old Jones ranch areas. However, the Rodriquez Tank sandstone is a continuous unit and commonly stands out forming a low ridge in the area of Ordovician outcrop in the Solitario and a prominent bench in the old Jones ranch locality.

FORT PEÑA FORMATION

General Features

The Fort Peña formation forms low prominent ridges throughout the Marathon basin. King (1931, p. 1070) designated one of the ridges directly north of old Fort Peña Colorada as the type locality. The formation has been so intensely deformed—commonly occurring in the crests of anticlines or troughs of synclines—that there are few places where more than a few feet crop out. The most complete exposures are along the southeast limb of the Marathon anticlinorium, but even here, the upper contact is seldom seen. A 229-foot section of the formation was measured on the southeast limb of the Marathon anticlinorium 2½ miles west of the Picnic Grounds (Pl. 1), and 225 feet were measured 3 miles to the southwest.

The formation consists of alternating

purple chert in layers 2 to 6 inches thick, black shale in layers 4 to 24 inches thick, brown-weathering, thin-bedded, generally cross-laminated, gray limestone in layers 4 to 18 inches thick containing orange-weathering chert stringers one-quarter to three-quarters inch thick, calcareous subgraywacke in layers 4 to 17 inches thick, and limestone and chert-pebble conglomerate in layers 3 to 10 inches thick. There is no rhythm to the alternations of lithologies; one rock type extends for several yards along strike and then passes into another rock type.

The lithologic character of the Fort Peña formation is remarkably uniform over its outcrop in the Marathon uplift. In the Solitario and old Jones ranch areas it includes thicker and more numerous shale and sandstone beds.

Local Features

Marathon anticlinorium.—In this anticlinorium, the formation forms secondary ridges below those of the white Caballos novaculite. A ridge of the Fort Peña formation parallels a ridge of the novaculite along the southeast flank of the Marathon anticlinorium. North of the town of Marathon, the formation crops out in hills of synclinal structure. The base of the formation in the northern part of the anticlinorium is marked by a layer of conglomerate 6 to 10 feet thick composed of chert and limestone pebbles one-quarter inch to 6 inches in diameter set in a gray arenaceous limestone matrix. Black shale or brown-weathering, gray, thin-bedded limestone is the basal bed of the formation in most places in the southern part of the anticlinorium. The shale beds increase in number and thickness near the top of the formation.

Dagger Flat anticlinorium.—Here the formation has been intensely folded so that typical exposures are found in low ridges that structurally are either troughs of synclines in subsidiary folds involving the Alsate shale and the upper part of the Marathon limestone or crests of anticlines in subsidiary folds involving the Woods Hollow shale. A conglomerate bed is present at the base of the formation in a few places, but in most, the basal unit is a brown-weathering, thin-bedded, gray limestone with orange-weathering chert stringers.

Old Jones ranch and Solitario areas.—The Fort Peña formation in the old Jones ranch and Solitario areas consists of the alternating brown-weathering, thin-bedded, gray limestone, purple chert, limestone pebble conglomerate, and black shale beds that are so characteristic of the formation in the Marathon basin. However, the shale beds are much thicker (up to 60 feet in thickness) and more numerous. A few thin beds of blue-gray-weathering, dark gray, sublithographic limestone are included near the base of the formation.

Fossils and Age

The limestones and shales of the Fort Peña formation contain graptolites and a few gastropods, ostracods, brachiopods, and conodonts. In some of the limestones, uncompressed or partially compressed biserial graptolite rhabdosomes have been preserved. These rhabdosomes have been highly carbonized so that no morphological details can be observed, and fine-grained white quartz sand now fills them. The limestones in which such rhabdosomes are found contain only a few scattered grains of quartz sand. The rhabdosomes apparently were filled with quartz sand and then transported into the area of limestone deposition. The uncompressed state of such highly carbonized remains is doubtless the result of the sand filling.

Enough distinctive assemblages of graptolites were collected from different levels in the formation so that two zones and part of a third may be proposed. The following check list (p. 22) includes all the graptolite species found in the formation and their zonal occurrence.

The basal beds of the Fort Peña formation are characterized by *Isograptus caduceus* var. *victoriae*, the typical form of *I. caduceus* and the name-giving species of the zone, and by the larger and more robust

varieties *I. caduceus* var. *maxima* and *I. caduceus* var. *maximo-divergens*. The genera *Oncograptus* and *Cardiograptus* are also characteristic of this lowest zone of the formation. Good collections of the typical zone fossils were made at localities 95, 107, 110, 140, and 141.

The second zone of the Fort Peña formation is characterized by the appearance of graptolites with a slender biserial scandent rhabdosome. *Hallograptus etheridgei*, the name-giving species, *Glyptograptus intersitus*, and *Trigonograptus ensiformis* are characteristic forms. Other common species are *Glossograptus acanthus*, *Glyptograptus* cf. *G. austrodentatus*, *Cryptograptus schaferi*, and *Didymograptus nodosus*. The Tetragrapti continue to be represented by *T. quadribrachiatus* and *T. serra*, but this is the last appearance of the tetragraptids in the section. The multiramous dichograptids also are seen for the last time in

Zonal distribution of species in the Fort Peña formation

SPECIES	ZONE		
	8	9	10
Amplexograptus confertus (Lapworth)	....	....	x
Amplexograptus cf. A. differtus Harris and Thomas	....	....	x
Brachiograptus etaformis Harris and Keble	....	x	....
Cardiograptus crawfordi Harris	x	....	....
Cardiograptus morsus Harris and Keble	x	....	....
Climacograptus riddellensis Harris	....	....	x
Cryptograptus schaferi (Lapworth)	....	x	....
Dichograptus marathonensis Berry, n.sp.	....	x	....
Dichograptus octobrachiatus (Hall)	....	x	....
Didymograptus compressus Harris and Thomas	....	x	....
Didymograptus cuspidatus Ruedemann	x	x	....
Didymograptus euodus Lapworth	x	....	....
Didymograptus nodosus Harris	....	x	....
Didymograptus pacificus Ruedemann	x	....	....
Didymograptus paraindentus Berry, n.sp.	x	....	....
Didymograptus v-deflexus Harris	x	....	....
Glossograptus acanthus Elles and Wood	....	x	....
Glossograptus hincksii (Hopkinson)	....	x	....
Glossograptus horridus Ruedemann	....	x	....
Glossograptus hystrix Ruedemann	....	x	....
Glyptograptus cf. G. austrodentatus (Harris and Keble)	x	x	....
Glyptograptus intersitus Harris and Thomas	....	x	....
Glyptograptus cf. G. teretiusculus (Hisinger)	....	....	x
Isograptus caduceus var. divergens Harris	x	x	....
Isograptus caduceus var. imitata Harris	....	x	....
Isograptus caduceus var. maxima Harris	x	....	....
Isograptus caduceus var. maximo-divergens Harris	x	....	....
Isograptus caduceus var. victoriae Harris	x	....	....
Isograptus forcipiformis var. latus Ruedemann	....	x	....
Isograptus manubriatus (T. S. Hall)	x	x	....
Isograptus ovatus (T. S. Hall)	....	x	....
Hallograptus echinatus (Ruedemann)	....	x	....
Hallograptus etheridgei (Harris)	....	x	....
Loganograptus logani (Hall)	....	x	....
Loganograptus logani mut. pertenuis Ruedemann	....	x	....
Oncograptus upsilon T. S. Hall	x	....	....
Oncograptus upsilon var. biangulatus Harris and Keble	x	....	....
Phyllograptus nobilis Harris and Keble	....	....	x
Phyllograptus typus Hall	x	....	....
Pterograptus incertus Harris and Thomas	....	x	....
Ptilograptus pulmosus (Hall)	....	x	....
Retiograptus speciosus (Harris)?	....	x	....
Retiograptus tentaculatus (Hall)?	....	x	....
Tetragraptus quadribrachiatus (Hall)	x	x	....
Tetragraptus serra (Brongniart)	....	x	....
Trichograptus immotus Harris and Thomas	....	x	....
Trigonograptus ensiformis (Hall)	x	x	....
Leperditella sp.	....	x	....
Paraschmidtella perforata (Harris)	....	x	....

this zone. The Isograpti are represented here by *I. forcipiformis* var. *latus* and *I. ovatus*—evolutionary modifications from *I. caduceus.*

Typical assemblages of the second zone can easily be obtained from the Alsate Creek section (measured section XVIII, collections 13, 14, 15, 16, 17, and 149) and from near the highway 1.5 miles south of Marathon, locality 28. Other collections from this zone were made at localities 117 and 152. The zone is approximately 150 to 160 feet thick.

The highest 10 to 20 feet of the Fort Peña formation and the basal 20 to 30 feet of the overlying Woods Hollow shale are characterized by the appearance of more robust biserial scandent rhabdosomes—of which the well-known, long-ranging *Glyptograptus* cf. *G. teretiusculus, Amplexograptus confertus,* and *Climacograptus riddellensis* are the most common forms. Associated with these species are *Amplexograptus* aff. *A. differtus* and the last of the Phyllograpti, *P. nobilis.* Good collections of the typical zonal assemblage were made at localities 85 and 92.

King (1937, p. 34) recorded *Ceraurus, Bucania,* and a rafinesquinoid brachiopod probably allied to *Ptychoglyptus* from the upper part of the formation near Garden Springs. The writer searched the outcrops around Garden Springs for more specimens of these fossils but none was found. Further, the writer has been unable to locate the original specimens at the U. S. National Museum or at The University of Texas.

The paucity of any well-preserved shelly fauna in the Fort Peña formation precludes a detailed correlation with the Middle Ordovician stages delimited by Cooper (1956). However, R. W. Harris (personal communication) identified *Leperditella* sp. and *Paraschmidtella perforata* from the second graptolite zone in the formation and stated that these forms indicate a possible correlation with the Oil Creek limestone of the Simpson group in the Arbuckle Mountains. Cooper (1956, correlation chart following p. 130) placed the Oil Creek limestone in the Whiterock stage. The lower and middle parts of the Fort Peña formation (graptolite zone 8 and at least part of zone 9) are therefore placed in the same stage. *Nemagraptus gracilis,* which is diagnostic of Cooper's Porterfield stage, appears 20 to 30 feet above the base of the Woods Hollow shale. The upper part of the Fort Peña formation and the lowest 20 to 30 feet of the Woods Hollow shale probably fall within Cooper's Marmor and Ashby stages, since they lie between rocks placed in the Whiterock stage and the Porterfield stage. The fauna of the Alsate shale, discussed above, is related to that of the Fort Peña formation, and the Alsate shale is grouped with the lower part of the Fort Peña formation in the Whiterock stage.

WOODS HOLLOW SHALE

General Features

In nearly all of its exposures, the Woods Hollow shale forms valleys between low ridges of the Fort Peña formation and the higher ridges of the Maravillas chert and the Caballos novaculite. The formation is the same as Baker and Bowman's members 4 and 5 of their Marathon series (table 1). It is completely exposed in an uncontorted condition in only one section—at the type locality in an anticlinal valley in the Woods Hollow Mountains. In all other outcrops the formation is intensely contorted, for the incompetent shales acted as a mobile band between chert and limestone of the Fort Peña formation below and the Maravillas chert above. Several exposures reveal thin limestone layers that have been broken, their ends rolled over, and the surrounding shales highly deformed.

Because it crops out principally in valleys, only a few feet of beds are exposed at any one place. In addition to the type locality in the Woods Hollow Mountains, good exposures were found on the northeast end of East Bourland Mountain, on Simpson Springs Mountain (Pl. 3, A), in several gullies near the Sunshine Springs thrust, and near the Right Hand Shut Up in the Solitario.

The formation consists of greenish-

weathering, black shale with interbedded layers of gray, thinly laminated limestone and tan-weathering, calcareous siltstone, each one-quarter to 1 inch thick, and lenses of yellow-brown weathering conglomerate composed of flattened pebbles of black shale scattered in a gray limestone matrix. The thin beds of limestone and siltstone are more numerous in the basal 60 to 80 feet of the formation.

The contact of the Woods Hollow shale and the Fort Peña formation is gradational. Where seen, the top 10 feet of the Fort Peña formation is thin-bedded, brown-weathering, gray limestone in layers a few inches thick with interbedded black shale, and the basal 20 feet of the Woods Hollow shale is thin-bedded, brown-weathering, gray limestone in layers up to 2 inches thick and gray shale pebble conglomerate lenses, both interbedded with greenish-weathering, black shale.

At a few localities, principally in the southwestern part of the Marathon basin, the upper 50 to 100 feet of the formation contains scattered, rounded boulders of Early Ordovician and Late Cambrian limestone. Baker and Bowman (1917) considered the boulders to be fossiliferous nodules in Late Cambrian and "Ozarkian" shale sequences unconformably underlying the Maravillas chert. They named the beds "Brewster formation" and "Member 1" of their "Marathon series." King (1931, p. 1064) recognized that the boulders were exotics in the Woods Hollow shale and abandoned the term "Brewster formation." Ulrich (*in* Baker and Bowman, 1917) identified faunas from the boulders and established their approximate age. Wilson (1954a) made a detailed study of the boulders and their faunas, and showed that the boulders contain trilobites belonging to the Atlantic as well as the North American faunal province. The presence of Atlantic province trilobites suggested to him the possibility of the distribution of Late Cambrian and Tremadoc trilobite faunas from the outer part of the Appalachian trough through the Ouachita geosyncline to the Andean trough following a facies belt. In Wilson's opinion, the blocks slumped off a Middle Ordovician fault scarp and were emplaced in the silty mud of the Woods Hollow formation by violent storms or turbidity currents. Because the blocks of any one rock type include at least one boulder 1 to 2 feet in diameter, a nearby point of origin is indicated.

Local Features

Woods Hollow Mountains.—The type locality of the Woods Hollow shale is in an anticlinal valley on the former Louis Granger ranch. Here, the entire formation, 436 feet thick, is clearly exposed overlying the highest beds of the Fort Peña formation, which crop out in the center of the valley. The lower part of the formation is thinly laminated, yellow-brown weathering, gray limestone and calcareous siltstone, each in layers one-half to 1 inch thick, with greenish-weathering, black shale partings. These layers grade up into the characteristic greenish-weathering, black shale with a few interbedded thin layers of gray limestone, siltstone, and shale pebble conglomerate. Four or five thin beds, one-half to 1 inch thick, of coarsely crystalline, gray limestone crowded with comminuted remains of brachiopods, bryozoa, trilobites, and crinoids occur near the middle part of the formation, and some of the shale beds in the upper part of the formation bear mud cracks.

Other localities.—The upper beds of the formation on the southeast limb of the Dagger Flat anticlinorium and on Simpson Springs Mountain contain more layers of thinly laminated, gray limestone interbedded with the black shale. Aside from these minor differences, the Woods Hollow shale is remarkably uniform in lithology, and apparently in thickness, throughout the entire Marathon region.

Fossils and Age

Graptolites are plentiful in the Woods Hollow shale but are poorly preserved and, because the shale breaks into small pieces, are difficult to collect. The best fossils are preserved along the bedding planes of the

thin limestone and some of the siltstones. Some poorly preserved ostracods were collected from the siltstones, and fragments of bryozoa and brachiopods were found in the thin beds of coarse-grained limestone. Although the formation is so highly deformed that only one complete section was found, enough graptolite collections were made from partial sections so that two and part of a third zone could be delimited in the formation. The following check list gives the zonal distribution of the fossils in the formation.

As was discussed under the Fort Peña formation, the basal 30 to 40 feet of the Woods Hollow shale and the upper 10 feet

Zonal distribution of species in the Woods Hollow shale

SPECIES	ZONE		
	10	11	12
Amplexograptus confertus (Lapworth)	x	....	....
Amplexograptus cf. A. differtus Harris and Thomas	x	....	....
Amplexograptus cf. A. perexcavatus (Lapworth)	....	....	x
Climacograptus antiquus var. bursifer Elles and Wood	....	....	x
Climacograptus bicornis (Hall)	....	....	x
Climacograptus eximius Ruedemann	....	x	x
Climacograptus modestus Ruedemann	....	....	x
Climacograptus modestus var. meridionalis Ruedemann	....	x	....
Climacograptus parvus Hall	....	x	x
Climacograptus riddellensis Harris	x	x	....
Climacograptus scharenbergi cf. var. stenostoma Bulman	....	x	x
Corynoides calicularis Nicholson	....	x	x
Corynoides incurvus Hadding	....	x	x
Corynoides tricornis Ruedemann	....	x	x
Cryptograptus tricornis (Carruthers)	....	x	x
Dicellograptus divaricatus (Hall)	....	x	x
Dicellograptus divaricatus var. salopiensis Elles and Wood	....	....	x
Dicellograptus gurleyi Lapworth	....	x	x
Dicellograptus gurleyi var. exilis Ruedemann	....	x	....
Dicellograptus intortus Lapworth	....	x	x
Dicellograptus moffatensis var. alabamensis Ruedemann	....	x	....
Dicellograptus patulosus Lapworth	....	x	....
Dicellograptus sextans (Hall)	....	x	x
Dicellograptus sextans var. exilis Elles and Wood	....	x	x
Dicellograptus smithi Ruedemann	....	x	x
Dicranograptus brevicaulis Elles and Wood	....	x	....
Dicranograptus contortus Ruedemann	....	x	....
Didymograptus saggiticaulis Gurley	....	....	x
Didymograptus serratulus (Hall)	....	x	x
Didymograptus subtenuis (Hall)	....	x	....
Diplograptus multidens Elles and Wood	....	....	x
Diplograptus multidens var. diminutus Ruedemann	....	....	x
Glossograptus armatus Nicholson	....	x	....
Glossograptus ciliatus Emmons?	....	x	x
Glossograptus hincksii (Hopkinson)	....	x	....
Glyptograptus teretiusculus (Hisinger)	....	x	x
Glyptograptus cf. G. teretiusculus (Hisinger)	x	....	....
Glyptograptus teretiusculus var. euglyphus (Lapworth)	....	x	x
Glyptograptus teretiusculus var. pygmaeus (Ruedemann)	....	....	x
Glyptograptus teretiusculus var. siccatus (Elles and Wood)	....	x	....
Hallograptus bimucronatus (Nicholson)	....	x	x
Hallograptus mucronatus (Hall)	....	....	x
Leptograptus flaccidus mut. trentonensis Ruedemann	....	x	....
Leptograptus validus var. incisus (Lapworth)?	....	x	x
Nemagraptus exilis var. linearis Ruedemann	....	x	x
Nemagraptus gracilis (Hall)	....	x	....
Nemagraptus gracilis var. surcularis (Hall)	....	x	....
Orthograptus calcaratus var. acutus (Lapworth)	....	....	x
Orthograptus calcaratus var. alabamensis (Ruedemann)	....	....	x
Orthograptus whitfieldi (Hall)	....	....	x
Retiograptus genitzianus Hall	....	x	x
Eurychilina papillata Harris	....	x	....
Eurychilina cf. E. subradiata Ulrich	....	x	....
Schmidtella sp.	....	x	....

of the Fort Peña formation comprise a zone characterized by *Glyptograptus* cf. *G. teretiusculus* and *Amplexograptus confertus*. Collections of the typical zone species were made from the Woods Hollow shale at localities 38, 46, and 46A.

The first complete zone in the formation is marked by the appearance of the familiar and diagnostic *Nemagraptus gracilis* and its associates in the genera *Nemagraptus, Dicellograptus,* and *Dicranograptus*. This zone of *N. gracilis* is marked by one of the most sudden bursts of new genera in the evolution of the Graptolithina. *N. gracilis* is not common in the zone; however, the zone can easily be recognized by the profusion of Dicellograpti and several species of the genera *Dicranograptus, Cryptograptus,* and *Leptograptus*. Diagnostic species of this zone, in addition to *N. gracilis,* are *N. exilis* var. *linearis, Leptograptus validus* var. *incisus?, Dicranograptus brevicaulis, Dicellograptus moffatensis* var. *alabamensis,* and *Dicellograptus sextans*. The Climacograpti and Glyptograpti, although common in this zone, are overshadowed by the abundance of Dicellograpti. *N. gracilis* and most other species and varieties of the Nemagrapti are restricted to this zone. Good collections were obtained from localities 49, 104, 122, 139, and 148. This zone comprises 260 to 280 feet of the formation.

The highest graptolite zone in the Woods Hollow shale, that of *Climacograptus bicornis,* is characterized by a continuation of the trend toward larger biserial scandent rhabdosomes, and by the widespread development of the well-known *Climacograptus bicornis*. Of the species with large biserial scandent rhabdosomes, *Diplograptus multidens* and *Orthograptus calcaratus* var. *alabamensis* are the most diagnostic of the zone. The Didymograpti, represented by the long, broad-striped species *Didymograptus saggiticaulis* and *D. serratulus,* are seen for the last time in this zone. Good collections of the typical zonal assemblage were obtained from localities 87, 94A, 100, 103, 105, 127, and 136. The upper 150 to 160 feet of the Woods Hollow shale is encompassed by this zone, and all the boulders discussed by Wilson (1954a) are within it. Characteristic zone fossils were collected from the shales surrounding the boulders at Simpson Springs Mountain and East Bourland Mountain.

King (1937, p. 35) reported *Diplograptus* from the lowest beds at the type locality of the formation and the bryozoa *Phaenopora, Nicholsonella, Rhinidictya,* and *Anolotichia,* the trilobites *Illaenus* and *Asaphus,* the molluscs *Modiolopsis* and *Holopea,* and the brachiopod *Orthis* from higher in the section at the same locality. King (1937, p. 36) also recorded *Ceraurus, Hormotoma, Dicellograptus, Diplograptus,* and *Glossograptus* from along the road between Ridge Spring and Garden Springs. The writer searched the Woods Hollow shale along the road between Ridge Spring and Garden Springs and all of the outcrops at the type locality for fossils other than graptolites but found only fragments of bryozoa and brachiopods in both localities.

Ulrich identified *Anolotichia* aff. *A. revalensis* Bassler, *Nicholsonella* sp., *Phaenopora* cf. *P. incipiens* Ulrich, *Stichtoporella* cf. *S. exigua* Ulrich, *Rhinidictya* sp., *Sowerbyella ("Plectambonites")* aff. *S. quinquecostata* (McCoy), *Eurychilina* sp., and *Aparchites* sp. from collections made 2 miles southwest of Lightning ranch by Böse (Baker and Bowman, 1917). The writer carefully searched the outcrops of the Woods Hollow shale in that area but was able to obtain only the following ostracods: *Eurychilina papillata, E.* cf. *E. subradiata, Eurychilina* sp., and *Schmidtella* sp. They came from near the middle of the formation, and R. W. Harris (personal communication) stated that they indicate a correlation with the lower part of the Bromide formation of the Simpson group in the Arbuckle Mountains, Oklahoma.

Since only fragments of brachiopods were obtained from the Woods Hollow shale, a close correlation with Cooper's (1956) stages of the Middle Ordovician is not possible. Cooper does indicate that *Nemagraptus gracilis* and its associates are found in the Porterfield stage. Further, he

places the lower part of the Bromide formation in that stage. Thus the basal beds of the Woods Hollow shale, those older than the zone of *N. gracilis*, are older than the Porterfield stage and fall within the Ashby stage. The zone of *N. gracilis* and possibly part of the overlying *C. bicornis* zone fall within the Porterfield stage. At least part of the *C. bicornis* zone probably is within the lower part of the Wilderness stage. The next younger zone in the Marathon sequence, that of *Orthograptus truncatus* var. *intermedius*, is a correlative of the basal part of the Viola limestone in the Arbuckle Mountains. Since Cooper places the basal part of the Viola limestone in the upper part of the Wilderness stage, a part, only, of the *C. bicornis* zone is placed in the lower part of that stage.

MARAVILLAS CHERT

General Features

Baker and Bowman (1917, p. 87) named the Maravillas chert for its exposures at Maravillas Gap, 20 miles southwest of Marathon. It crops out on the inner slopes of the novaculite-capped ridges that are so characteristic of the Marathon region. Its black cherts and limestones stand out in marked contrast to the white novaculite above them. Good exposures are present in the cliffs that rise above the swimming pool at the Picnic Grounds 5 miles southwest of Marathon, at Rock House Gap located at the southwestern end of the southeast limb of the Marathon anticlinorium, and on the northwest slope of Threemile Hill, 3¼ miles northeast of Maravillas Gap (Pl. 1).

The formation is composed of layers of black chert 6 to 8 inches thick alternating with light-gray weathering, black, petroliferous limestone layers 4 to 8 inches thick (Pl. 3, B). Also, it includes some interbedded lenses of chert and limestone pebble conglomerate, a few thin, pink-weathering shale partings, and a few layers of subgraywacke 4 to 6 inches thick, some of which exhibit graded bedding. Both the black chert and the limestone are lenticular and intergrade along strike. Black chert predominates over limestone in the upper 150 to 200 feet of the formation, but the difference is not sufficient to warrant separation of this part as a distinct member.

The rocks of the Maravillas chert reflect a sharp change in the sedimentary environment. The chert and limestones overlie the Woods Hollow shale conformably, and although a coarse conglomerate is found at the base of the Maravillas chert in some places, paleontologic evidence has not revealed any considerable temporal break between the two formations.

The Maravillas chert ranges in thickness from 200 to 250 feet in the Marathon anticlinorium; it thickens southeastward to about 350 feet on the northwest limb of the Dagger Flat anticlinorium and is nearly 400 feet thick on the southeast limb. It apparently thins farther to the south, because it is about 200 feet thick in the old Jones ranch area and about the same thickness in the Solitario.

Local Features

Marathon anticlinorium.—The uppermost 5 feet of the formation exposed in the ridge trending northeast from the swimming pool is composed of interbedded pink-weathering shale and chert in layers half an inch to 3 inches thick. The shale contains latest Ordovician graptolites. Similar graptolites have been obtained from limestones at the top of the formation in several localities. Because of the contained fossils and the resemblance of the pink-weathering shale to shale partings in the middle part of the Maravillas chert, the shales are included in the Maravillas formation and are not referred to a younger formation as suggested by Wilson (1954b, p. 2470). The lower 50 feet of the formation includes numerous beds of chert and limestone pebble conglomerate (the pebbles range in size from one-eighth inch to about 2 inches in diameter) which contain fragments of bryozoa and trilobites.

A basal conglomerate about 10 feet thick is exposed at Rock House Gap. Black chert and black limestone pebbles are common

in the conglomerate, but it also includes rock types not found in the Marathon region, such as a brownish, medium-grained, quartzose sandstone and pinkish dolomite. Abraded remains of corals are present in the coarse-grained, brown, quartz sand matrix. The conglomerate is a lens and passes into black chert along strike.

Dagger Flat anticlinorium.—At Threemile Hill and at the type locality, Maravillas Gap, the Maravillas chert is bounded at its base by the major fault plane of the Threemile Hill thrust. Near the middle of the section at both of these localities several beds of coarse-grained calcarenite 2 to 10 feet thick contain abundant fragments of bryozoa and trilobites. Similar coarse-grained calcarenite beds, but thinner and less fossiliferous, crop out near the middle of the formation on the southeast flank of the Dagger Flat anticlinorium north from Threemile Hill.

Southern exposures.—Chert predominates over limestone in all exposures south of the Marathon basin. On Rough Creek, in the Dove Mountain quadrangle, the formation consists of black chert in layers 3 to 10 inches thick with a few interbedded layers of black limestone 4 to 6 inches thick. In the old Jones ranch area and at Persimmon Gap, the entrance to Big Bend National Park on State Highway 51, the upper 20 to 40 feet of the formation consists of black chert in layers 4 to 10 inches thick; whereas lower in the section, black chert, black limestone, and a few chert and limestone pebble conglomerate lenses are interbedded. In the several exposures of the formation along the northeastern front of the Santiago Mountains, the formation consists of interbedded layers of black chert 4 to 8 inches thick and a black limestone 4 to 6 inches thick. At the Right Hand Shut Up in the Solitario, 154 feet of the formation is exposed in a section that has been intruded by sills. Here it is nearly all black chert with only a few black limestone lenses, but other outcrops of the formation in the Solitario include some black limestone in beds 2 to 4 inches thick interbedded with the black chert.

Fossils and Age

Fragments of fossils are present throughout the Maravillas chert, but the preservation is so poor that identification is difficult. Graptolites have been collected from the limestones in all parts of the formation. The conglomerates at the base of it have yielded abraded remains of corals and brachiopods. Fragments of trilobites and ostracods were collected from the black fine-grained limestones, some of the limestone pebble conglomerates, and from the coarse-grained calcarenite beds that are crowded with bryozoa. In addition to several species of bryozoa and a few trilobites and ostracods, these beds have also yielded brachiopods and corals. Scattered through the black cherts are sponge spicules and some Radiolaria, but no attempt has been made to classify these fossils. Enough graptolites have been collected from the limestones to identify three zones in the formation. The following check list (p. 29) gives the zonal distribution of fossils in the formation.

The lowest zone is characterized by the appearance of large Orthograpti, the following species of which are typical: *Orthograptus truncatus* var. *intermedius, O. quadrimucronatus* var. *angustus, O. quadrimucronatus* var. *cornutus,* and *O. calcaratus* var. *incisus. Climacograptus typicalis* var. *crassimarginalis* and *Dicranograptus nicholsoni* are two other species that are common. The trilobites *Cryptolithus* and *Ampyxina* and the coral *Streptelasma* were collected from the basal beds of the zone. Collections of the typical zonal assemblage were made at localities 73, 86B, 128, 133, 134, 134A, and 135.

King (1937, p. 41) recorded *Columnaria, Halysites, Paleofavosites, Streptelasma, Platystrophia,* and *Hebertella* from the basal conglomerate of the Maravillas chert at Rock House Gap. From limestones overlying the conglomerate, he obtained *Cryptolithus, Harpes, Strophomena, Cli-*

Zonal distribution of species in the Maravillas chert

SPECIES	ZONE 13	14	15
Climacograptus antiquus Lapworth	x	....	....
Climacograptus caudatus Lapworth	x	x	....
Climacograptus hastatus T. S. Hall	....	....	x
Climacograptus minimus (Carruthers)	....	x	....
Climacograptus mississippiensis Ruedemann	....	....	x
Climacograptus putillus (Hall)	....	....	x
Climacograptus scalaris var. miserabilis Elles and Wood?	....	....	x
Climacograptus scharenbergi Lapworth	x	....	....
Climacograptus spiniferus Ruedemann	x	....	....
Climacograptus tubuliferus Lapworth	....	x	....
Climacograptus typicalis Hall	x	x	....
Climacograptus typicalis var. crassimarginalis Ruedemann and Decker	x	....	....
Climacograptus cf. C. ulrichi Ruedemann	....	....	x
Dicellograptus complanatus Lapworth	....	....	x
Dicellograptus complanatus var. arkansasensis Ruedemann	....	....	x
Dicellograptus complanatus var. ornatus Elles and Wood	....	....	x
Dicellograptus forchammeri (Geinitz)?	....	x	....
Dicellograptus forchammeri var. flexuosus Lapworth	x	....	....
Dicellograptus pumilus Lapworth	....	x	....
Dicranograptus nicholsoni Hopkinson	x	....	....
Dicranograptus nicholsoni var. geniculatus Ruedemann and Decker	x	....	....
Diplograptus crassitestus Ruedemann	....	....	x
Diplograptus minutus Berry, n.sp.	....	x	....
Leptograptus annectans (Walcott)	....	x	....
Orthograptus calcaratus (Lapworth)?	....	x	....
Orthograptus cf. O. calcaratus var. basilicus Lapworth	....	x	....
Orthograptus calcaratus var. incisus (Lapworth)	x	....	....
Orthograptus cf. O. calcaratus var. vulgatus (Lapworth)	x	x	....
Orthograptus quadrimucronatus (Hall)	....	x	....
Orthograptus quadrimucronatus var. angustus (Ruedemann)	x	....	....
Orthograptus quadrimucronatus var. cornutus (Ruedemann)	x	....	....
Orthograptus aff. O. truncatus (Lapworth)	x	x	....
Orthograptus truncatus var. abbreviatus (Elles and Wood)?	....	....	x
Orthograptus truncatus var. intermedius (Elles and Wood)	x	....	....
Orthograptus truncatus var. pertenuis (Ruedemann)	x	x	....
Orthograptus truncatus var. recurrens (Ruedemann)	....	x	....
Orthograptus truncatus var. socialis (Lapworth)	....	....	x
Retiograptus deckeri Ruedemann	....	....	x
Retiograptus pulcherrimus Keble and Harris	x	x	....
Cryptolithus sp.	x	x	....
Ampyxina sp.	x	....	....
Flexicalemene sp.	....	x	....
Hallopora sp.	....	x	....
Helopora sp.	....	x	....
Christiana? sp.	x	....	....
Paterula sp.	x	....	....
Streptelasma sp.	x	....	....
Zygospira sp.	x	....	....

macograptus antiquus, Diplograptus amplexicaulis, and *"Dicellograptus" nicholsoni*. The last-named form must be a misprint since there is no species *"nicholsoni"* of the genus *Dicellograptus*. In the genus *Dicranograptus*, however, *"nicholsoni"* is a well-known species and is characteristic of this horizon. King (1937, p. 41) records a list of ostracods, brachiopods, a trilobite, and a graptolite identified by Ulrich from collections made by Baker and Bowman at Rock House Gap. The writer re-examined this collection at the U. S. National Museum and confirms the identification of *Diplograptus amplexicaulis (Orthograptus* aff. *O. truncatus* herein), *Aparchites* sp., *Eurychilina*, and *Cryptolithus*. Cooper (personal communication) identified an immature *Christiana?* and *Paterula* from this collection. King (1937, p. 41) lists a few graptolites which Ruedemann identified from three localities north of the town of Marathon.

The second zone in the Maravillas chert

is characterized by several species of large Orthograpti associated with large Dicellograpti. *Orthograptus quadrimucronatus* (the typical form) is the most widespread and diagnostic species of this zone. Other characteristic species include *Climacograptus tubuliferus, Dicellograptus forchammeri?, Orthograptus* cf. *O. calcaratus* var. *vulgatus,* and *Orthograptus* aff. *O. truncatus.* The trilobites *Flexicalymene* and *Cryptolithus* and the bryozoa *Hallopora* were identified in collections made within this zone at Threemile Hill. Collections of the typical zone species were obtained from localities 45, 55, 83A, 86A, and 132.

King (1937, p. 41) reproduced from Baker and Bowman (1917, pp. 89–90) a list of bryozoa and brachiopods which they collected at Maravillas Gap and which Ulrich identified. Baker and Bowman (1917, p. 90) added a second list of corals and brachiopods. King (1937, p. 41) stated that the calcarenite lenses composed of bryozoa and other fossils found in the middle part of the Maravillas chert in the southern part of the Marathon uplift are "built of such genera as *Constellaria* and *Pachydictya,* in which are imbedded a few shells of *Platystrophia, Rafinesquina, Hebertella.*" The writer searched the Maravillas chert at Maravillas Gap for bryozoa and brachiopod material similar to that collected by Baker and Bowman but was able to find only some poorly preserved specimens. Further, the writer was unable to locate the original collection on which Ulrich worked at the U.S. National Museum. The bryozoan calcarenite beds from which the writer collected at Threemile Hill are in the second zone in the Maravillas chert.

The third zone in the formation is characterized by *Dicellograptus complanatus* and its varieties, by three small species of *Climacograptus,* and by *Diplograptus crassitestus.* The Orthograpti are represented by two small varieties of *Orthograptus truncatus—O. truncatus* var. *socialis* and *O. truncatus* var. *abbreviatus?.* A form like the typically lower Silurian species *Climacograptus scalaris* var. *miserabilis* was found here also. Good collections of the typical species of the zone were obtained from localities 60, 138, and 147. The zone is about 50 feet thick.

The writer found no fossils other than graptolites in the upper 100 feet of the Maravillas chert. These beds are composed predominantly of chert; however, Bassler (1950, p. 19) listed five species of corals characteristic of the Richmond stage from the Maravillas chert but gave neither stratigraphic nor locality data.

The age of the Maravillas chert has been the subject of considerable discussion. Schuchert (*in* Udden, 1907) considered the first fossils found in the chert-limestone sequence to be of Trenton age. Ulrich (*in* Baker and Bowman, 1917) considered the lower part of the Maravillas chert to be correlative with the middle and upper part of the Viola limestone in the Arbuckle Mountains and the Trenton limestone of New York, because he regarded the fossils Baker and Bowman collected from the base of the formation at Rock House Gap to be of Trenton age. Further, he stated that the fauna of bryozoa and brachiopods from Maravillas Gap was a "typical Fernvale-Richmond fauna," and he considered that the upper part of the formation had a similar relation to the Trenton part as the Fernvale-Richmond zone had to the Viola limestone in Oklahoma. Ulrich thought that the Fernvale-Richmond zone and its correlatives marked a great transgression following a period of emergence and placed it at the base of the Silurian. Thus Ulrich divided the Maravillas chert (as he did other western formations such as the Montoya limestone and Bighorn dolomite) into a lower part correlated with the Trenton and an upper part correlated with the Fernvale-Richmond.

Kirk (1930, p. 465) gave his opinion that the "*Cryptolithus* zone" of the Maravillas chert was probably of Cincinnatian age. He used Cincinnatian in the sense of pre-Richmond and post-Trenton. King (1937, p. 41) reported that Kirk had collected *Cryptolithus* from the "reef beds on Threemile Hill." Fragments of this trilobite

are abundant in the calcarenite beds composed of bryozoa and other organisms at Threemile Hill, and, as discussed above, these beds fall within the second graptolite zone in the formation. King (1931, p. 1075; 1937, pp. 41–42) assigned Late Ordovician age to the Maravillas chert, and it is placed in the Richmond stage in the Ordovician correlation chart (Twenhofel et al., 1954).

The graptolite fauna of the formation displays a gradual change so that three zones are recognized. The discussion of the age of the formation involves the graptolites principally, because the other fossils are too poorly preserved and are not found at regular enough intervals to be useful for detailed work.

The fauna of the Denmark limestone of the type Trenton includes the graptolite species *Orthograptus truncatus* var. *intermedius* which is the most characteristic species of the lowest graptolite zone in the Maravillas chert. The writer examined Ruedemann's collections at the New York State Museum in Albany and recognized this species from the Denmark limestone only. It had not been collected from the lower beds of the Trenton stage.

The writer examined Decker's collections from the Viola limestone which are at the University of Oklahoma. The following species were recognized from collections made near the base of the formation: *Dicellograptus forchammeri* var. *flexuosus*, *Dicranograptus nicholsoni*, *Climacograptus typicalis* var. *crassimarginalis*, *Orthograptus truncatus* var. *intermedius*, and *Orthograptus quadrimucronatus* var. *spinigerus*. Four of these species are common to both the basal part of the Viola limestone and the lowest zone of the Maravillas chert, including the diagnostic *O. truncatus* var. *intermedius*. The lowest zone in the Maravillas chert, the lower part of the Viola limestone, and the Denmark limestone in the type Trenton are considered correlatives. Because Cooper (1956) placed the base of the Viola limestone in the upper part of the Wilderness stage, the base of the Maravillas chert is placed in the same part of this stage.

The graptolite fauna of the second zone in the Maravillas chert can be correlated with the graptolite fauna of the Lorraine group in New York. The most diagnostic species are *Orthograptus quadrimucronatus* and *Climacograptus typicalis* which are common in both the Maravillas chert and in the Lorraine group. *Climacograptus typicalis* is also found in the Southgate formation of the Eden group in Cincinnati. The Lorraine group was correlated with the Eden and part of the Maysville by Ruedemann (1925a) and this correlation was followed in the Ordovician correlation chart (Twenhofel et al., 1954). Zone 2 in the Maravillas chert is correlated with the Eden and Maysville stages. The *Cryptolithus* zone mentioned by Kirk (1930, p. 465) is in zone 2, and the writer agrees with the Cincinnatian age proposed by Kirk for the particular part of the formation in which he found the fragments of *Cryptolithus* so abundant.

The graptolite fauna of the third zone in the Maravillas chert is correlative with the highest Ordovician graptolites in the English and Australian sequences. Since the zone is evidently post-Maysville and latest Ordovician in age, it must be Richmond, although the type Richmond has but three little-known graptolites. Also, the Sylvan shale in Oklahoma has a fauna very similar to the third zone and it is placed in the Richmond stage in the Ordovician correlation chart (Twenhofel et al., 1954). The Maravillas chert represents late Middle Ordovician and all of Late Ordovician time. The original diagnosis by Ulrich of a Trenton fauna and a Richmond fauna in the formation is correct, but the Eden and Maysville are also represented. There is no break in time within the Maravillas chert; there seems to have been continuous deposition from late Wilderness time through the Trenton and all of the Late Ordovician.

DEPOSITIONAL HISTORY OF THE ORDOVICIAN STRATA

From a consideration of the rock types and their planktonic fauna—graptolites—a few conclusions concerning the conditions of deposition may be inferred. The Marathon limestone includes calcilutite, current-laminated beds of fine-grained calcarenite, shale, many conglomerate lenses, and some subgraywacke lenses. These subgraywackes, like those higher in the succession, are composed of grains of quartz, plagioclase, sericite, and glauconite, and fragments of calcarenite. The cementing material is predominantly calcite. The source of the clastic material doubtless lay to the south, because areas to the west, north, and east were sites of carbonate deposition during Early Ordovician time. Also, the formation includes more shale and thicker subgraywacke layers in its more southerly exposures (the old Jones ranch and Solitario areas) than it does in the main uplifts. The dip of the cross-lamination in the calcarenite layers indicates the last current acting came from the southwest. This current may have been a longshore current operating at an angle to the actual direction from which the sediment came.

For a short period in the middle part of Early Ordovician time, patch reefs grew extensively in the area of the present Marathon anticlinorium and to a lesser extent in the Dagger Flat anticlinorium area. These oval lenses, composed of calcilutite surrounded by a network of dolomite, characterize the Monument Spring dolomite member and contain a different fauna from the surrounding rocks. The reef masses were probably built up by algae which acted as trappers and binders of bioclastic lime debris. Cup-shaped sponges were secondary parts of the framework—forming widely spaced tie points between which the algae grew. In and around this mass, gastropods, nautiloids, and brachiopods flourished. The reef masses were small mounds and doubtless resembled in size and possibly in shape small patch reefs found in the lagoons of many modern coral atolls. They probably grew during a period of quiescence when the larvae of bottom-dwelling organisms floated into the region and were able to settle and grow successfully on the sea floor. After a time, wave action increased and coarser-grained sediment went into suspension and washed around and over the reefs, ending their growth.

Some of the calcarenites in the formation are penetrated by small tubes filled with comminuted material, perhaps left by a burrowing animal. Also, a few of the calcareous shale layers bear mud cracks. These features, in addition to the reefs, the intraformational conglomerate, the cross-lamination, and the pellet and aggregate structures in the calcilutites, indicate that the Marathon limestone was deposited in an area covered by shallow water subjected to wave and current action and which, at least in places, was temporarily exposed and became a mud flat. The area appears to have been a shelf, possibly with some local highs. A land mass lay to the south; it contributed only a little noncalcareous material to the northern part of the region but a considerable amount to the southern part.

Carbonate formation ceased during deposition of the Alsate black shale in the areas of the present main uplifts and of the Rodriquez Tank quartzose sandstone in the old Jones ranch and Solitario areas. Although the sandstone is exposed only in two areas, it is very similar in both and may well have been a continuous nearshore deposit. Possibly an uplift had occurred to the south so that the shore line was near the present sites of the Solitario and old Jones ranch. A relatively small amount of fine-grained sediment was carried to the northern part of the Marathon region. The present Marathon basin was occupied by a stable water mass and reducing conditions prevailed.

Black shale deposition was apparently of short duration; then carbonate deposition returned. The rocks of the Fort Peña formation consist of alternating layers of medium- and fine-grained, cross-laminated

calcarenite, chert composed of radiating fibers of chalcedony, black shale, and lenses of subgraywacke and chert and limestone pebble conglomerate. The dip of the current laminae indicates that the last current to pass over the calcarenite beds came from the southwest. Also, several beds with biserial graptolites arranged with their long axes subparallel were found near the top of the formation. The proximal (narrow) ends of the rhabdosomes point S. 25° W. to S. 40° W., indicating that the last current to pass over these rhabdosomes came from the southwest. As indicated above, the cross-laminated calcarenite layers were probably deposited above wave base in shallow water.

The calcarenites of the Fort Peña formation become more thinly laminated near the top and grade into the thinly laminated fine-grained calcarenites and the shales of the overlying Woods Hollow formation. The environment in the depositional area slowly changed to one in which mud was being deposited. Currents periodically swept different material into the area of black mud accumulation. In some cases, the currents carried fine sand-sized grains of calcite and in other cases, silt and fine sand-sized quartz grains. In some places, the currents ripped fragments of shale from the bottom and incorporated the fragments with the material they were carrying. Nearly all the fossils found in the formation came from the siltstone and calcarenites. The fossils are poorly preserved—showing signs of transport. The graptolites with biserial rhabdosomes are commonly aligned with their proximal ends pointing southwest. Some of the shale layers bear mud cracks, and the presence of them indicates that the water became shallow in the Marathon region during the time of deposition of the Woods Hollow shale. From time to time, parts of the area were temporarily exposed. The presence of mud cracks is at present considered good evidence of shallow water. However, subaqueous shrinkage cracks are a possibility, although their formation in a layer has not been demonstrated (Pettijohn, 1957, p. 193). The region may have been a large mud flat across which water fluctuated and into which silt and sand-sized material was carried periodically by currents generated by storms.

The exotic boulders described by Wilson (1954a) occur in the upper 15 to 70 feet of the Woods Hollow shale. The boulders are slabs with rounded corners and are composed of several types of limestone not found in the Marathon region. They range from several inches to 10 feet in length and are found in a rather restricted area on the southwest side of the Marathon basin. The shale around the slabs is intensely contorted, and the slabs occur as isolated masses. Fragments of other materials are not present. The slabs were probably derived from a rising highland, possibly to the west, and the processes which produced them may have been related to the general disturbances which affected much of the geosynclinal area in eastern North America during the latter part of the Middle Ordovician.

The black limestones and cherts of the Maravillas chert represent a change in the sedimentary environment in the Marathon region. The formation is composed of interbedded chert, composed of a fine-textured mass of cryptocrystalline quartz, and calcilutite with some lenses of intraformational conglomerate, subgraywacke, and pinkish-weathering shale.

The black silica and lime muds could be the product of reducing conditions either in the water mass or below the water-sediment interface. When such conditions prevail below the interface, rapid sedimentation is taking place to prevent oxygenation of the sediment. The absence of a bottom-dwelling fauna and the fact that the 200 to 400 feet of sediment now comprising the Maravillas chert was deposited during a long period of time (from late Middle Ordovician through Latest Ordovician), indicate that the reducing environment was above the water-sediment interface. A stable water mass persisted over the bottom of the present Marathon region throughout the time during which the rocks of the

Maravillas chert were being deposited. The water may have been either shallow or deep; however, it was shallow enough so that the bryozoa, trilobites, and corals, which now form coarse-grained calcarenite beds, could thrive in local patches. These patches were areas of the sea floor where water circulation was sufficient to overcome the reducing conditions temporarily and permit growth of the bottom-dwelling organisms. The areas were local in extent and the bottom-dwelling fauna flourished for a short time and then was overcome by toxic water from adjacent areas. Also, currents ripped limestone and chert pebbles from the sea floor and incorporated them into conglomerates from time to time.

Fine-grained deposits of calcium carbonate and silica slowly accumulated in the reducing environment. A nearby land mass was probably the source for the quartz and feldspar in the subgraywacke lenses. Because of the freshness of the feldspar in the subgraywacke, such a land mass does not seem to have undergone enough chemical activity to supply silica only. Thus it probably was not the source of colloidal silica as King (1937, p. 46) postulated. Sediments similar to those in the Marathon region were being deposited northwest of it. Limestone was being deposited for several hundred miles northward. Therefore, there does not appear to have been a suitable source for silica in the colloidal form.

Graptolite-bearing rocks may be either deep or shallow-water deposits (Bulman, 1955, pp. V16–V17). From a study of the Ordovician strata in the Marathon region, a shallow-water origin may be postulated for the lower and middle parts of the succession, but evidence is inconclusive for the upper part. During much of the time of deposition of the Ordovician succession, the bottom was foul and probably the waters were turbid. These conditions are unfavorable to the growth of a bottom-dwelling fauna. Thus graptolites—pelagic organisms—and a few inarticulate brachiopods that could withstand a wide variation in environmental conditions are found as the principal fossils. Only during the development of the reef patches in the middle part of Early Ordovician time and the bryozoa in the middle part of Late Ordovician time, were bottom-dwelling organisms able to thrive in any part of the Marathon region.

Devonian System

Overlying the Maravillas chert is a sequence of white novaculites and varicolored cherts and shales. This sequence was named the Caballos novaculite by Baker and Bowman (1917, p. 93) who designated Horse Mountain as the type locality. King (1937), after a detailed study of the formation, divided it into five members. The writer and Nielsen (1958) discussed the regional aspect of the members and showed that the lowest member—a brown chert—overlies the Maravillas black cherts and limestones in the Marathon basin. In the Solitario, old Jones ranch, and Persimmon Gap exposures, the pink shales of King's third member overlie the Maravillas chert. Graves (1952) described conodonts from the upper part of the Caballos novaculite and interpreted the fauna to be of Late Devonian age.

CORRELATION

Correlation Within North America

The details of the fauna found in each formation have been discussed. Graptolites are plentiful throughout the sequence and 15 zones have been delimited. Although other elements of the fauna are few, and recent detailed work on the graptolite-bearing rocks in other regions is lacking, some correlations can be made (table 2). Good correlation is possible with the well-known Ordovician graptolite-bearing rocks of Quebec and New York.

A few fossils only have been collected from the Schaghticoke shale in New York, but the presence of *Dictyonema canadense* (Bulman, 1950a, p. 72), *Staurograptus dichotomus* var. *apertus*, and *Bryograptus patens* in this shale and in the Matane shale of Quebec indicates similarity in age between these two formations. The Matane shale contains a more varied graptolite fauna (Bulman, 1950a), including species of *Anisograptus* and *Triograptus*. These latter two genera and the genus *Staurograptus* are represented in zone 1 of the Marathon sequence and indicate a probable correlation between this zone and the Matane shale. Thus the lowest zone of the Marathon succession, the Matane shale of Quebec, and the Schaghticoke shale of New York are considered correlatives.

The *Clonograptus-Adelograptus* assemblage which characterizes zone 2 of the Marathon sequence has been recorded from but one other locality in North America. Kindle and Whittington (1958, p. 331) have collected the typical zonal assemblage from western Newfoundland.

The correlation between the Marathon limestone and the standard Lower Ordovician section has been discussed above under the heading "Fossils and age of the Marathon limestone" (pp. 15–19). As was pointed out in that discussion, the presence of *Bellefontia* in zone 1 and *Ophileta*, etc., in zone 2 suggests that zone 1 and at least part of zone 2 may be correlated with the Gasconade dolomite of this standard section.

Raymond's (1914) zone A of the Levis shale and zone 3 of the Marathon sequence have similar faunas, the following species being common to both: *Clonograptus flexilis, Clonograptus rigidus, Tetragraptus approximatus, Tetragraptus quadribrachiatus,* and *Tetragraptus serra.* Of these species, *T. approximatus,* which is confined to zone 3 in the Marathon succession, is the most characteristic form in both areas. The fauna of the Monument Spring dolomite member, which as discussed earlier (p. 17) lies within zone 3, can be correlated with the Rich Fountain formation in the standard Lower Ordovician section for the United States and with the middle part of the Kindblade formation in the Arbuckle Mountains.

Raymond's (1914) zones B, C-1, and C-2 of the Levis shale and Ruedemann's (1902) zone 1 and zone 2, bed 1, of the Deepkill shale contain many of the same species as zones 4, 5, and 6 of the Marathon succession. The writer has seen the diagnostic forms of *Tetragraptus fruticosus* (4-branched and 3-branched varieties) in collections from the Levis and Deepkill shales, and thus this species has been collected from all three areas. Zone 1 of the Deepkill section and zone 4 of the Marathon section have 12 species common to both. Miser and Purdue (1929, p. 27–28) listed an assemblage of graptolites from the Mazarn shale that are common in zone 4 of the Marathon limestone. This collection is the oldest obtained from the Ordovician section of the Ouachita Mountains. Two of the underlying formations, the Crystal Mountain sandstone and the Collier shale, have arbitrarily been included in the Ordovician system. The Collier shale has yielded indeterminate fragments which may be graptolites but no age determination is possible.

Didymograptus protobifidus, the diagnostic species in zone 6 in the Marathon

Table 2. Correlation of graptolite-bearing sequences in North America

	Stages	GRAPTOLITE ZONES	MARATHON	OUACHITAS	ARBUCKLES	NEW YORK	QUEBEC
UPPER ORDOVICIAN	Richmond	15. D. complanatus	Maravillas	Polk Creek	Sylvan Fernvale	Queenston Oswego	
	Maysville Eden	14. O. quadrimucronatus		Bigfork	Viola	Lorraine group Upper Utica	
MIDDLE ORDOVICIAN	Trenton	13. O. truncatus var. intermedius		Womble		Loyal Creek Nowadaga Canajoharie	Magog
	Wilderness	12. C. bicornis	Woods Hollow		Bromide	Normanskill	
	Porterfield	11. N. gracilis			Tulip Creek		
	Ashby	10. G. cf. G. teretiusculus	Fort Peña		McLish		
	Marmor					Deepkill (Zone 3)	Levis (Zone D)
	Whiterock	9. H. etheridgei		Blakely	Oil Creek		
		8. I. caduceus	Alsate				
		7. D. bifidus	Marathon	Mazarn	Joins	Deepkill (Zones 1–2)	Levis (Zones A–C)
LOWER ORDOVICIAN	Stages not yet estab- lished	6. D. protobifidus			West Spring Creek		
		5. T. fruticosus (3-br. and 4-br.)					
		4. T. fruticosus (4-br.)					
		3. T. approximatus			Kindblade		
		2. Clonograptus		Crystal Mountain	Cool Creek		
		1. Anisograptus		Collier	McKenzie Hill	Schaghticoke	Matane

succession, is known from the West Spring Creek formation in the Arbuckle Mountains and from the Smithville limestone of the standard Lower Ordovician section. Since *D. protobifidus* is limited to zone 6, that zone, the Smithville limestone, and the West Spring Creek formation are considered correlatives.

The graptolite assemblage which is characteristic of zone 7 of the Marathon sequence has been recorded by Raymond (1914) from zone C-3 of the Levis shale and by Ruedemann (1902) from zone 2, bed 2, of the Deepkill shale. The diagnostic species of zone 7, *Didymograptus bifidus*, has been found in all three areas. Further, eight identical species have been found in the Deepkill shale and zone 7 of the Marathon limestone, and four species are common to both zone C-3 of the Levis shale and zone 7 of the Marathon limestone. The diagnostic species of the zone, *Didymograptus bifidus* and *D. artus*, have been collected from the Joins formation in the Arbuckle Mountains and from the Black Rock limestone of the standard Lower Ordovician section (Ruedemann, 1947, pp. 326–327). As has been pointed out above, Cooper (1956) has placed the Joins formation in the early Middle Ordovician. Therefore, its correlatives, the Black Rock limestone and zone 7 of the Marathon limestone, would also be early Middle Ordovician in age.

Raymond's (1914) zone D of the Levis shale and Ruedemann's zone 3 of the Deepkill shale each contain two species—*Tetragraptus quadribrachiatus* and *Trigonograptus ensiformis*—found in zone 8 in the Fort Peña formation in the Marathon region. Both of these species range into zone 9 in the Marathon sequence, and, in addition, three species found only in zone 9 are found in zone D of the Levis shale and five species restricted to zone 9 are in zone 3 of the Deepkill shale. Thus, zone D of the Levis shale and zone 3 of the Deepkill shale are tentatively correlated with zone 9 only, of the Marathon region. Miser and Purdue (1929) list species of the genera *Didymograptus, Glossograptus, Glyptograptus,* and *Isograptus* from the Blakely sandstone, and Ruedemann (1947, pp. 95–96) listed two faunas from exposures of that formation near Hot Springs, Arkansas. One list included *Loganograptus logani, Isograptus caduceus* var. *nanus,* and *Didymograptus euodus.* The presence of *I. caduceus* in the formation indicates a probable correlation with zone 8 of the Marathon sequence. The second list included *Climacograptus pungens, Glyptograptus dentatus, Glossograptus horridus,* and *Glossograptus hystrix.* These forms indicate a probable correlation with zone 9 of the Marathon succession. Thus the Blakely sandstone is correlated with the Alsate shale and with most of the Fort Peña formation. A few ostracods were collected from the upper part of the Fort Peña formation, zone 9. R. W. Harris (personal communication) identified *Leperditella* sp. and *Paraschmidtella perforata* (Harris) in a collection from this zone and stated that they indicate a correlation with the Oil Creek formation of the Simpson group in the Arbuckle Mountains. M. E. Upson, of Gulf Oil Corporation (personal communication), has identified ostracods from the upper part of the Fort Peña formation which are typical of the McLish formation of the Simpson group and ostracods from the Woods Hollow shale which are typical of the Tulip Creek formation of the Simpson group. The ostracods typical of the Tulip Creek formation came from graptolite zone 11 which is in the Woods Hollow shale. Thus graptolite zone 10 and possibly part of zone 9 are correlatives of the McLish formation, and at least part of graptolite zone 11 is a correlative of the Tulip Creek formation.

Graptolite zones 11 and 12 have a distinctive fauna that includes several species in common with the Normanskill shale of New York and the lower and middle parts of the Womble shale in the Ouachita Mountains. Also, Decker (1952) has recorded many occurrences of the typical assemblages of zones 11 and 12 in his discussion of the "Athens" shale. Ostracods characteristic of the lower part of the Bromide

formation of the Simpson group in the Arbuckle Mountains were collected from the middle part of the Woods Hollow shale, which is in graptolite zone 11 (zone of *N. gracilis*). Cooper (1956) correlated the Bromide formation with the lower and middle parts of the Womble shale. Since, using graptolites, the Woods Hollow shale and the lower and middle parts of the Womble shale may be correlated, the Woods Hollow shale, the lower and middle parts of the Womble shale, and the Bromide formation are considered correlative.

The writer examined Decker's collections from the Bigfork chert and the Viola limestone at Oklahoma University, and Ruedemann's collection from the Snake Hill, Canajoharie, Utica, Deer River, and Atwater Creek shales and from the Lorraine group at the New York State Museum. The assemblage of large orthograptids which characterizes graptolite zone 13, the basal part of the Maravillas chert, is well developed in the Snake Hill and Canajoharie shales, in the Nowadaga and Loyal Creek members of the Utica shale in New York, and in the Magog shale in Quebec. Also, the lower part of the Viola limestone and the upper part of the Womble shale have several species in common with graptolite zone 13. Further, the most characteristic form in zone 13, *Orthograptus truncatus* var. *intermedius*, was identified by the writer in Ruedemann's collections from the Trenton limestone from Trenton Falls near Middleville, New York. King (1937, p. 41) listed a few ostracods collected from rocks which are within zone 13. Ulrich worked on King's collection and identified six genera but was able to determine the species of only one of them. All of the genera are recorded from the Bromide formation (Harris, 1939), but they all apparently have some range in time since all are also found in the Decorah formation (Kay, 1940). The Decorah has been put in the Trenton stage by Cooper (1956).

Graptolite zone 14, the middle part and some of the upper part of the Maravillas chert, the Bigfork chert, and the middle and upper parts of the Viola limestone have a few species in common, including *Dicellograptus forchammeri, Orthograptus truncatus* var. *recurrens*, and *Leptograptus annectans*. In New York, the Holland Patent, Deer River, and Atwater Creek shales and the Lorraine group have a few species of graptolites in common. These species include *Orthograptus quadrimucronatus, Orthograptus truncatus* var. *recurrens*, and *Climacograptus typicalis*. The species *O. quadrimucronatus, O. truncatus* var. *recurrens, C. typicalis*, and *L. annectans* are common to both the New York and Marathon successions, and zone 14 is considered correlative with the Holland Patent, Deer River, Atwater Creek, and Lorraine formations in New York.

The highest 50 feet of the Maravillas chert, zone 15, the Polk Creek shale in the Ouachita Mountains, and the Sylvan shale in the Arbuckle Mountains have nearly identical graptolite faunas. The species *Dicellograptus complanatus, Diplograptus crassitestus*, and *Climacograptus mississippiensis* are particularly common in all three formations.

Intercontinental Correlation

A complete sequence of graptolite zones for the Ordovician system has been delineated in the Marathon region, and the correlation of some other graptolite-bearing rocks in North America with that zonal sequence has been considered. Complete sequences of Ordovician graptolite zones have been recognized in two other areas in the world. The most famous of these was worked out in the British Isles by Elles and Wood (1901–1918). Elles (1925) set forth the important features of the British zones in a concise manner. The other complete sequence is that in Victoria, Australia, where T. S. Hall, Harris, Keble, Thomas, and others have collected graptolites stratigraphically for over 100 years. Several zonal schemes have been proposed for parts of the Victorian succession (Hall, 1899b, and Harris and Keble, 1932), but Harris and Thomas (1938b) have published the most recent discussion of the Australian

zones, and their work embraces all of the Ordovician system.

Table 3 shows an attempt at correlation between the Marathon, Victorian, and British graptolite zones for the Ordovician system. The correlation of the stages and series of the Ordovician system in each area follows from the correlation of the graptolite zones. The Victorian and Marathon sequences are quite similar throughout, but the British sequence in the Early and early Middle Ordovician is dissimilar.

The lowest beds in the Ordovician sys-

Table 3. Correlation of Ordovician sequences in the United States (Marathon area), Australia (Victoria), and the British Isles based on graptolite zones.

UNITED STATES	Zone	AUSTRALIA	Zone	BRITISH ISLES	Zone
Richmond	15	Bolindian	25	Ashgill	15 14
Maysville Eden	14		24	Caradoc	13 12
Trenton	13	Eastonian	23 22		11
Wilderness	12	Gisbornian	21		10
Porterfield	11		20		9
Ashby	10	Middle Ordovician	19 18 17 16	Llandeilo	8
Marmor	9	Yapeenian	15 14	Llanvirn	7
Whiterock	8	Castlemainian	13 12 11		6
	7	Chewtonian	10 9 8		
	6	Bendigonian	7 6 5 4	Arenig	5 4 3
Canadian series	5 4				
	3	Lancefieldian	3 2		2
	2 1		1	Tremadoc	1

tem in Victoria, the Lancefield series, have been subdivided into three zones. The lowest zone is marked by the appearance of *Staurograptus* with two provincial species of *Dictyonema*. The lowest zone in the Marathon succession is characterized by the genus *Anisograptus*, but the fauna includes *Staurograptus*, which is restricted to the lowest zone.

Zone 2 in the Marathon succession and the second zone in the Lancefield series contain several identical species including *Clonograptus rigidus, Tetragraptus decipiens, Adelograptus hunnebergensis, A. victoriae*, and *A. simplex*. These two zones are, therefore, considered correlatives.

The third zone in the Marathon succession and the third zone of the Lancefield series also contain many identical species. The most diagnostic species of both zones is *Tetragraptus approximatus*. Associated with it are *Clonograptus rigidus, C. flexilis, Tetragraptus quadribrachiatus*, and *Dichograptus octobrachiatus*.

The appearance of *T. approximatus* and its associates marks the beginning of rapid speciation within the genera *Didymograptus* and *Tetragraptus*. This speciation reaches its full development in the overlying strata. The complex composed of species of these two genera has been subdivided into three zones in the Marathon region and six zones in Victoria. The rocks which are included in these six zones in Australia are much thicker than the rocks which comprise the corresponding zones in the Marathon region. In the Victorian succession, the complex of Tetragrapti and extensiform Didymograpti is found in the Bendigo and most of the Chewton series. The complex has been divided as follows:

Bendigo series: basal zone characterized by *T. approximatus* with *T. fruticosus* (four-branched); second zone denoted by *T. fruticosus* (four-branched) without either *T. approximatus* or *T. fruticosus* (three-branched); third zone marked by the appearance of *T. fruticosus* (three-branched) with *T. fruticosus* (four-branched); fourth zone typified by *T. fruticosus* (three-branched) without *T. fruticosus* (four-branched).

Chewton series: lowest zone marked by the appearance of the dependent didymograptid *D. protobifidus* with *T. fruticosus* (three-branched); second zone characterized by *D. protobifidus* with *T. fruticosus* (three-branched) being rare.

The three zones in the Marathon region which encompass the complex of Tetragrapti and extensiform Didymograpti have been delimited as follows: zone 4 is characterized by the appearance of *T. fruticosus* (four-branched) without either *T. approximatus* or *T. fruticosus* (three-branched); zone 5 is marked by *T. fruticosus* (three-branched) appearing with *T. fruticosus* (four-branched); and zone 6 is marked by the appearance of *D. protobifidus* with both the three- and four-branched forms of *T. fruticosus*. Thus the same theme of appearance of *T. fruticosus* (four-branched), then *T. fruticosus* (three-branched), then *D. protobifidus* obtains in both the Victorian and Marathon sequences.

Zone 4 of the Marathon sequence is considered correlative with the lower two zones of the Bendigo series. Although the lowest zone of the series includes *T. approximatus*, the presence of *T. fruticosus* (four-branched) with several other species of Tetragrapti and Didymograpti in the same zone in Victoria makes the correlation of this zone with Marathon zone 4 more plausible than correlating it with Marathon zone 3. Zone 5 of the Marathon sequence and the third zone of the Bendigo series are characterized by the same forms (the three- and four-branched forms of *T. fruticosus* together) and they contain many identical species. The correlation of the highest zone of the Bendigo series with the Marathon zonal scheme is difficult, because the four-branched form of *T. fruticosus* ranges into the zone with *D. protobifidus* in Marathon but does not range above the third zone of the Bendigo series in Victoria. The fourth and highest zone of the Bendigo series does have a number of species identical to those found in both zones 5 and 6 in

the Marathon succession, and the writer arbitrarily correlates the lower part of it with Marathon zone 5 and the upper part with Marathon zone 6. The lowest zone of the Chewton series and Marathon zone 6 are marked by the appearance of *D. protobifidus*, and they contain several identical species. The second zone in the Chewton series, characterized by *D. protobifidus* with *T. fruticosus* (three-branched) rare, is also correlated with zone 6. Thus Marathon zone 6 is believed to be equivalent to part of the highest zone of the Bendigo series and the lower two zones of the Chewton series.

Zone 7 of the Marathon sequence is characterized by the dependent didymograptids *D. artus* and *D. bifidus*, which give an important tie with the British zones (see p. 43). The fauna of the highest zone of the Chewton series is poorly known and may be the correlative of zone 7, since it lies above the zone with *D. protobifidus* and below the zone with *Isograptus caduceus* var. *lunata* in the Victorian succession. These two forms occur respectively below and above *D. bifidus* in the Marathon sequence.

The Castlemaine series in Victoria has been divided into three zones based on the appearance in succession of varieties of *Isograptus caduceus*. The succession is, in order of appearance, *I. caduceus* var. *lunata*, *I. caduceus* var. *victoriae*, and *I. caduceus* var. *maxima*. The succeeding series, the Yapeen, has been divided into two zones, the lower of which is the zone of *Oncograptus* and the upper is the zone of *Cardiograptus*. *I. caduceus* var. *lunata* appears first in the Marathon region, but the other varieties of *I. caduceus* and the genera *Oncograptus* and *Cardiograptus* occur together; and, in fact, *I. caduceus* var. *victoriae*, *Oncograptus upsilon*, and *Cardiograptus morsus* have been found together on the same bedding plane. Further, *Trigonograptus ensiformis* and *Didymograptus v-deflexus* occur with *Oncograptus* and *Cardiograptus* in both the Victorian and Marathon sequences. Thus zone 8 in the Marathon region, which includes *Oncograptus*, *Cardiograptus*, and the several varieties of *I. caduceus*, is correlated with both the Castlemaine and Yapeen series in Victoria.

The Middle Ordovician, as recognized in Victoria, includes four zones, while rocks containing the same species in the Marathon region have been found divisible into only two zones. All of the important species of the lower two zones and the lower part of the third zone of the Middle Ordovician of Victoria were found in zone 9 in the Marathon sequence. Harris (1935) listed the characteristic assemblages of graptolites in each zone of the Victorian Middle Ordovician, and by comparing these lists to the list of the fauna from zone 9, it will be noted that *Glyptograptus austrodentatus* and *I. caduceus* var. *divergens*, characteristic of the lowest zone of the Victorian Middle Ordovician; *Glyptograptus intersitus*, *Hallograptus etheridgei*, *Cryptograptus schaferi*, and *Glossograptus acanthus*, characteristic of the second zone of the Victorian Middle Ordovician; and *Didymograptus nodosus*, *Hallograptus etheridgei*, and *Didymograptus cuspidatus*, characteristic of the lower part of the third zone of the Victorian Middle Ordovician, are all found in zone 9. The diagnostic species in the upper part of the third zone of the Victorian Middle Ordovician (*Amplexograptus confertus*, *A. differtus*, and *Phyllograptus nobilis*) and diagnostic species of the fourth and highest zone of the Victorian Middle Ordovician (*Glyptograptus teretiusculus* and *Climacograptus riddellensis*) comprise the fauna of zone 10 in the Marathon sequence.

The fauna of the Upper Ordovician in Victoria has not been worked out in detail stratigraphically, nor fully described. Thomas and Keble (1933) published lists of graptolites collected from various Upper Ordovician localities, but only recently (Harris and Thomas, 1955) has any systematic paleontology been done on the Late Ordovician faunas. Harris and Thomas (1938b) gave a brief list of the diagnostic species of each zone. Three series were distinguished in the Victorian Upper Ordo-

vician. In ascending order they are Gisbornian, Eastonian, and Bolindian. Two zones were recognized in the Gisbornian series; the lower is the zone of *Nemagraptus gracilis* and the upper is the zone of *Climacograptus peltifer*. Zones 11 (zone of *N. gracilis*) and 12 (zone of *Climacograptus bicornis*) in the Marathon sequence contain many of the same species as are reported in the two zones in the Gisbornian. Two zones were also recognized in the Eastonian series. The lower zone includes the species *Dicranograptus nicholsoni* and *Orthograptus truncatus*, both of which are common in zone 13 of the Marathon sequence. Zone 14 in the Marathon region includes elements of both the upper zone of the Eastonian series (*Climacograptus tubuliferus*, *C. minimus*, *Orthograptus calcaratus* var. *vulgatus*) and of the lower zone of the Bolindian series (*Orthograptus quadrimucronatus* and *Dicellograptus forchammeri*). The highest zone of the Marathon sequence, zone 15, and the highest zone of the Bolindian series are characterized by *Dicellograptus complanatus* and *D. complanatus* var. *ornatus*.

Thus the Victorian and Marathon zonal sequences are quite similar for all of Ordovician time. However, the lower and middle parts of the British sequence are rather dissimilar to the lower and middle parts of the Marathon and Victorian sequences, and correlation between the areas is far more difficult.

The lower zone of the Tremadoc series, the lowest zone in the British succession, is denoted by varieties of the species *Dictyonema flabelliforme*, but these forms do not occur in either North America or Australia. However, Bulman (1954) in a study of the *Dictyonema* shales (lower Tremadoc) of the Oslo region, Norway, pointed out the possibility that the Matane shale in Quebec, which is a correlative of the lowest zone in the Marathon sequence, may be lower Tremadoc in age. The genus *Anisograptus*, which is diagnostic of zone 1 in the Marathon region, was found in the Oslo region with the varieties of *Dictyonema flabelliforme* which characterize the lower Tremadoc. The lowest zones of the Victorian and Marathon areas are correlatives, and both are probable correlatives of the lower zone in the Tremadoc series in the British Isles.

The rocks comprising the upper part of the Tremadoc series and the basal part of the Arenig series do not contain graptolites in the type localities of these series. However, Elles (*in* Elles and Wood, 1901–1918) suggested a second zone at the top of the Tremadoc and a third zone at the base of the Arenig.

As recognized by Elles, the second zone of the British sequence is characterized by the appearance of *Clonograptus* and species now placed in the genus *Adelograptus*. These two genera are diagnostic of the second zone of both the Victorian and Marathon sequences. Although the genera are the same in both the British and Marathon-Victorian sequences, only one species, *Clonograptus tenellus* var. *callavei*, is found to be common to the British and the Marathon zonal assemblages. The writer considers the second zone in all three sequences to be correlative.

According to Elles (1922), the third British zone, the lowest of the Arenig series, is characterized by the multiramous dichograptids *Clonograptus flexilis* and *Dichograptus octobrachiatus* in the lower part and by the incursion of tetragraptids in the upper part. However, recent work has led Bulman (1958, p. 164) to state that there is no stratigraphic evidence for the existence of this zone.

The complex of tetragraptids and extensiform didymograptids, so characteristic of zones 4, 5, and 6 in the Marathon region and of the Bendigo and part of the Chewton series in Victoria, is also found in the British Isles. It has been divided into two main zones (zones of *Didymograptus extensus* and *D. hirundo*) (Elles and Wood, 1901–1918), and Elles (1933) subdivided the *D. extensus* zone into four subzones. Detailed correlation between the subzones and the Marathon and Victorian zones is tenuous, however. *Didymograptus protobifidus* appears first in the British succes-

sion in the third subzone, that of *Didymograptus nitidus,* and it appears in zone 6 of the Marathon sequence and in the lowest zone of the Chewton series in Victoria. The presence of this early dependent didymograptid indicates the possibility that the lower two subzones of the *D. extensus* zone may be correlative with the Bendigo series in Victoria and with zones 4 and 5 in the Marathon region. Zone 6 in Marathon and the lower two zones of the Chewton series in Victoria both are typified by *D. protobifidus* and include *D. protobifidus—D. bifidus* transients. The third subzone of the *D. extensus* zone contains *D. protobifidus,* and the highest subzone and the succeeding zone, that of *D. hirundo,* both have *D. protobifidus—D. bifidus* transients. Thus zone 6 in the Marathon region, the lowest two zones of the Chewton series, and the upper two subzones of the *D. extensus* zone plus the *D. hirundo* zone are probable correlatives.

The two species which are diagnostic of zone 7 in the Marathon sequence, *Didymograptus artus* and *D. bifidus,* are also the diagnostic species of the sixth zone, the basal zone of the Llanvirn series, in the British Isles. The occurrence of these two important species as zonal indicators in both the British and Marathon successions affords a good tie point between these two otherwise dissimilar zonal subdivisions of the lower and middle parts of the Ordovician system. The highest zone of the Chewton series is correlated with zone 7 in the Marathon region and is thus a probable correlative of the sixth zone in the British Isles.

The highest subzone of the *D. extensus* zone of the British succession includes *Isograptus, Oncograptus* (Cummins, 1954), *Glyptograptus dentatus,* and *Trigonograptus ensiformis* with the complex of tetragraptids and extensiform didymograptids and the *D. protobifidus—D. bifidus* transients. The writer considers the appearance of the dependent didymograptids with the extensiform types and with the tetragraptids and the subsequent appearance of *D. bifidus* and *D. artus* to be more important for correlation than the presence of *Isograptus, Oncograptus, Glyptograptus,* etc., which appear in zone 8 in the Marathon region and in the Castlemaine and Yapeen series in Australia. Contrary to the opinion of others (Ripper, 1937; Harris and Thomas, 1938b), the writer believes that the *Isograptus, Oncograptus,* and biserial scandent forms appear in older beds in the British sequence than they do in the Victorian and Marathon. These forms are less common in the British sequence than they are in either the Marathon or Victorian and appeared in Britian first, then in North America and Australia.

The seventh zone of the British sequence, the upper of the Llanvirn series, has few elements in common with the Marathon and Victorian successions. However, the eighth zone, that of the Llandeilo series, is characterized by the presence of *Glyptograptus teretiusculus* in abundance, and the same criterion is used to delimit zone 10 of the Marathon sequence and the uppermost zone of the Middle Ordovician in Victoria. Zone 7, the upper zone of the Llanvirn series, is correlated with zones 8 and 9 in the Marathon sequence and with the Castlemaine and Yapeen series and the lower three zones of the Middle Ordovician in Victoria because of its stratigraphic position.

With the incursion of *G. teretiusculus* in abundance in all three zonal successions, similar assemblages appear in the same sequence in all three areas during the remainder of Ordovician time. Harris and Thomas (1938b) used the same zone names as the British (with the exception of that of *Dicellograptus anceps,* the fauna of which, they stated, is included in the zone of *Dicellograptus complanatus*), and they indicated that the fauna of each zone is quite similar to that of the British zones.

Nemagraptus gracilis and its associates mark zone 11 in the Marathon region, the basal zone of the Gisbornian series in Australia, and the basal zone of the Caradoc series in the British Isles. Zone 12 in the Marathon region, the upper zone of the Gisbornian series in Victoria, and the tenth

zone in the British succession have many species in common and are characterized by the incursion of large Orthograpti, the presence of *Climacograptus bicornis* and its variety *peltifer,* and the absence of the Nemagrapti. The appearance of several species of large orthograptids marks zone 13 in the Marathon region, the lower zone of the Eastonian series in Victoria, and the eleventh zone of the British sequence. The form *Orthograptus truncatus* var. *intermedius* is common in both Marathon zone 13 and the eleventh British zone. Zone 14 in the Marathon succession contains elements of both zones 12 (zone of *Dicranograptus clingani*) and 13 (zone of *Pleurograptus linearis*) of the British sequence and is probably correlative with both, but no subdivision is feasible in the Marathon region. The species *Orthograptus truncatus* and *Orthograptus calcaratus,* which occur in zone 14, are diagnostic of the zone of *D. clingani,* and *Orthograptus quadrimucronatus,* which is common in zone 14, is diagnostic of the zone of *Pleurograptus linearis* in the British Isles. The upper zone of the Eastonian series in Victoria contains the same characteristic species as zone 12 (the zone of *D. clingani*) in the British Isles, and the lower zone of the Bolindian series has *O. quadrimucronatus* and *P. linearis,* which are distinctive of zone 13 in the British Isles.

The forms *Dicellograptus complanatus* and *D. complanatus* var. *ornatus* are characteristic of the uppermost zone of the Marathon sequence, zone 15, and are found in the upper zone of the Bolindian series in Australia. In the British Isles, *D. complanatus* is the diagnostic element of zone 14, the lower zone of the Ashgill series, and the variety *ornatus* occurs with *D. anceps* in zone 15. Elles (1937, pp. 488–489) stated that the zone of *D. complanatus* is conditional and omitted it from her charts of the zones. Zone 15 of the Marathon sequence includes species (*Orthograptus truncatus* var. *abbreviatus?* and *Dicellograptus complanatus* var. *ornatus,* etc.) found in the *D. anceps* zone in the British Isles, and hence it is correlated with the Ashgill series there.

Thus the Marathon and Victorian zonal sequences are quite similar throughout but are dissimilar to the British sequence until the Llandeilo. From then on, the zonal assemblages in all three areas are similar. North America and Australia belonged to one graptolite faunal region and the British Isles were a part of another during pre-Llandeilo time. From that time throughont the remainder of the Ordovician, graptolite species occurred in similar assemblages in the same sequence in all three areas.

SYSTEMATIC PALEONTOLOGY

The writer has followed Bulman's (1955) taxonomic subdivisions as published in the section on Graptolithina in the Treatise on Invertebrate Paleontology. Reference is made to the Elles and Wood (1901–1918) and Ruedemann (1904, 1908, and 1947) monographic works on the Graptolithina and to the more readily accessible Australian publications for detailed descriptions of the species and subspecies. Differences between the Texas specimens and the published descriptions are noted, and the geographic and geologic range of each species and subspecies is given.

Class GRAPTOLITHINA Bronn, 1846

Order DENDROIDEA Nicholson, 1872

Family DENDROGRAPTIDAE Roemer (*in* Frech, 1897)

Genus DICTYONEMA Hall, 1851

DICTYONEMA DUMOSUS Berry, n. sp.

Pl. 7, fig. 10

Description.—The rhabdosome is broadly conical and medium-sized, measuring 1.7 cm in length and 2.5 cm in width. The stipes are wavy, are 0.2 to 0.3 mm in width, number 15 to 16 in 10 mm in the mature portion of the rhabdosome, and divide frequently at first but subsequent divisions are spaced farther and farther apart. The stipes divide at acute angles (20 to 30 degrees) but become subparallel immediately. The space between the stipes is 1 mm in the mature portion of the rhabdosome. Dissepiments are infrequent and are as thick as the stipes. The dissepiments usually occur between stipes when the bulge or wave in one stipe nearly touches a similar bulge in the stipe next to it. The thecae are indistinct but the autothecae appear to number 14 to 16 in 10 mm, and in flattened profile view may be seen alternating on both sides of the stipes, giving them wrinkled outer edges.

Horizon.—The specimens of this species were collected from one locality (collection 101) which is in zone 4 in the upper part of the Marathon limestone.

Holotype.—Yale Peabody Museum No. 20251.

Family ANISOGRAPTIDAE Bulman, 1950

Genus ANISOGRAPTUS Ruedemann, 1937

ANISOGRAPTUS DISSOLUTUS Berry, n. sp.

Pl. 4, figs. 5, 6

Description.—The rhabdosome is triradiate and horizontal, with somewhat flowing branches which bifurcate at increasing intervals. The three first-order branches are 2.0 to 2.8 mm in length, and commonly one is longer than the other two. Bifurcations occur at intervals of 2.0 to 2.8 mm, 3.0 to 4.0 mm, and 4.5 to 5 mm up to the fourth order, above which, branching is irregular and does not occur in some stipes. The first-order stipes are 0.3 mm wide, while the fifth and sixth order stipes are 0.6 to 0.7 mm in width. The thecae number 11 to 12 in 10 mm. The autothecae have a nearly straight ventral margin, a slightly concave apertural margin, and overlap about one-half their length.

This species resembles *A. flexuosus* in its lax shape and the tangle formed by the distal branches. It differs from that form in the branching, the number of thecae per 10 mm, and the lack of denticles on the autothecae.

Horizon.—Specimens of this species were collected from the lower part of the Marathon limestone, zone 1 (collection 84A).

Holotype.—Yale Peabody Museum No. 20255.

Genus ADELOGRAPTUS Bulman, 1941

ADELOGRAPTUS HUNNEBERGENSIS (Moberg)?

Pl. 5, figs. 2, 8

Remarks.—The Texas specimens are poorly preserved and are small. However, they agree with the specific description given by Moberg (1892) and the more complete discussion by Stubblefield (1929) in the following characteristics: the length

of the sicula (1.0 mm), the angle of the divergence of the primary stipes (130 to 140 degrees), the dichotomy just past the opening of the third theca, the number of the thecae per 10 mm (8 to 9 in 10 mm), and the concave apertural margins of the thecae. The thecal overlap of the Texas specimens is about one-third their length, while in the type material the thecae overlap one-half their length. Also, the primary stipes in the Texas specimens are 0.5 to 0.7 mm in width, while the same stipes are 0.8 mm in width in Stubblefield's picture. Because of the smaller size and the poor preservation of the Texas material, they are only tentatively referred to *A. hunnebergensis.*

Horizon.—The specimens provisionally referred to this species were collected from low in zone 2 (collections 11 and 59) in the lower part of the Marathon limestone. Stubblefield records *A. hunnebergensis* from the Shineton shales (Tremadoc in age) in Shropshire. Moberg originally described the species from rocks of Tremadoc age in Sweden.

ADELOGRAPTUS PUSILLUS (Ruedemann)

Bryograptus pusillus Ruedemann, 1904, N. Y. State Mus., Mem. 7, pp. 641, 642, pl. 4, figs. 21, 22.

Bryograptus pusillus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 299, pl. 49, figs. 3, 4 (not figs. 5, 6).

Remarks. — Bulman (1941) removed pendent multiramous dichograptids with two primary stipes from the genus *Bryograptus* and placed them in the genus *Adelograptus.* Two primary stipes originate from the sicula in the species *pusillus* and hence it belongs in the genus *Adelograptus.* The Texas specimens agree closely with Ruedemann's original specific description. The forms from the Glenogle shale figured by Ruedemann (1947) as *Bryograptus pusillus* (Pl. 49, figs. 5, 6) appear to the writer to belong to the genus *Pterograptus.*

Horizon.—*A. pusillus* was obtained from zone 4 in the upper part of the Marathon limestone (collection 71). Ruedemann (1947) reports the species from bed 2 of the *Tetragraptus* zone of the Deepkill shale in New York.

ADELOGRAPTUS SIMPLEX (Tornquist)

Bryograptus simplex Tornquist, 1904, Lunds Univ. Arsskrift, Bd. 40, Afdeln 1, no. 2, pp. 3–4, pl. 1, figs. 1–4.

Bryograptus simplex Benson and Keble, 1935, Royal Soc. New Zealand, Trans., vol. 65, p. 270, pl. 30, figs. 12, 13.

Adelograptus simplex Bulman, 1941, Ann. Mag. Nat. Hist., ser. 11, vol. 7, p. 115.

Remarks.—The Texas specimens agree in all essential characters with Tornquist's description except that the inclination of the thecae is slightly less than in the type material and as a consequence, the stipes are not quite so wide. Many of the Texas forms are immature.

Horizon.—Specimens of this species were collected from the lower part of the Marathon limestone, zone 2 (collections 33, 37, and 72E). Tornquist's type material came from the lower *Phyllograptus* shales (zone of *Tetragraptus phyllograptoides*) in Sweden. Benson and Keble (1935) state that in New Zealand, the species occurs occasionally in the lowest zone of the Bendigo series but is more common in the zones below, the upper two zones of the Lancefield series. Harris and Thomas (1938b) figure *A. simplex* as common in the second zone of the Lancefield series of Victoria, Australia. The species occurs with the same associates (*A. victoriae, Tetragraptus decipiens,* and *Clonograptus flexilis*) in the Lancefield series and zone 2 in the Marathon sequence.

ADELOGRAPTUS VICTORIAE (T. S. Hall)

Bryograptus victoriae T. S. Hall, 1898, Royal Soc. Victoria, Proc., vol. 11, p. 165, pl. 17, figs. 1, 2.

Adelograptus victoriae Bulman, 1941, Ann. Mag. Nat. Hist., ser. 11, vol. 7, p. 115.

Remarks.—The Texas specimens agree closely with Hall's specific description.

Horizon.—Specimens of *A. victoriae* were collected from the lower part of the Marathon limestone (collections 33, 43, 72E, 74, and 89), where it is a characteristic element of the fauna of zone 2. Harris and Keble (1932) list the species as a common form of the second zone in the

Lancefield series of the Lower Ordovician of Victoria, Australia. *A. victoriae* occurs with the same associates (*Clonograptus rigidus, Adelograptus simplex,* and *Tetragraptus decipiens*) in both the Victorian and Marathon sequences.

Genus BRYOGRAPTUS Lapworth, 1880

BRYOGRAPTUS CRASSUS Harris and Thomas?

Pl. 5, fig. 9

Remarks.—The Texas specimens are poorly preserved but three primary stipes appear to be present, thus indicating the generic affinities are with *Bryograptus* rather than *Adelograptus.* No more than four secondary stipes were seen in any of the Texas material, while Harris and Thomas (1938a, pp. 72–73, pl. 1, figs. 7a-d, pl. 4, fig. 6) figure forms with four to six secondary stipes. Harris and Thomas mention two primary stipes only, but three primary stipes appear to be present in the Texas specimens. However, the Texas specimens agree with Harris and Thomas' specific description in the width of the stipes, in the angle of divergence of the stipes, and in the manner in which the stipes branch.

Horizon.—The specimens tentatively referred to *B. crassus* were collected from the lower part of the Marathon limestone, zone 2 (collections 33 and 37). The type specimens of *B. crassus* came from the basal zone of the Bendigo series in Victoria, Australia; the Texas forms occur at a lower horizon than do the Australian.

Genus CLONOGRAPTUS Hall and Nicholson, 1873

CLONOGRAPTUS FLEXILIS (Hall)

Pl. 6, fig. 4

Graptolithus flexilis Hall, 1858, Geol. Survey Canada, Rept. Prog. for 1857, pp. 119, 145.
Clonograptus flexilis T. S. Hall, 1899, Royal Soc. Victoria, Proc. (n.s.), vol. 11, p. 169, pl. 19, fig. 20.
Clonograptus flexilis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 280–281, pl. 44, figs. 4–9.

Remarks.—The measurements of the Texas specimens agree with those given by Ruedemann, except that the funicle length of the Texas forms is slightly less (2.0 mm compared to 2.5 mm in the type material).

Horizon.—Specimens of *C. flexilis* were collected from zones 2, 3, and 4 in the lower and middle parts of the Marathon limestone (collections 2, 11, 33, 69, 76, and 97B). The species was described by J. Hall from the Levis shale in Quebec, and Raymond (1914) found it there in association with *C. rigidus* and *Tetragraptus approximatus* and placed the assemblage in his lowest zone, zone A. This assemblage is identical to that of zone 3 in the Marathon succession. Harris and Thomas (1938b) record *C. flexilis* from the lower two zones of the Lancefield series in Victoria, Australia, where it occurs with the same associates as it does in zones 2 and 3 of the Marathon sequence.

CLONOGRAPTUS PERSISTENS Harris and Thomas

Pl. 5, fig. 11

Clonograptus persistens Harris and Thomas, 1939, Min. and Geol. Jour., vol. 2, p. 59, fig. 11.

Original diagnosis. — Rhabdosome of typical clonograptid aspect, up to 14 cm in diameter, the longest stipes measured, usually those produced by the last dichotomy, being 3.5 cm long. Funicle 4 mm in length. Stipes up to the fifth or seventh order are found, all the stipes being of approximately the same width—about 1.5 mm. Thecae 9 to 10 in 10 mm, inclined at 25 to 45 degrees, with convex ventral margins, overlapping for half their length.

Remarks.—The Texas specimens agree with the above description except that the fourth order stipes are slightly longer than those shown in the figure of the Australian specimen.

Horizon.—*C. persistens* was found to be a common element of zone 2, in the lower part of the Marathon limestone (collections 12 and 33). Harris and Thomas state that their type specimen came from the lowest zone of the Bendigo series in Victoria, Australia. The species occurs there at a slightly younger horizon than it does in the Marathon region.

CLONOGRAPTUS RIGIDUS (Hall)

Pl. 5, fig. 10; Pl. 7, fig. 15

Graptolithus rigidus Hall, 1858, Canadian Nat. Geol., vol. 3, p. 146.
Clonograptus rigidus T. S. Hall, 1899, Royal Soc. Victoria, Proc. (n.s.), vol. 11, p. 170, pl. 18, fig. 22, pl. 19, fig. 21.
Clonograptus rigidus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 281–282, pl. 44, figs. 10, 11.

Remarks.—The Texas specimens agree well with the description by Ruedemann. The stipes are rigid and definitely thicker than those of *C. flexilis*, which is quite like *C. rigidus* in other respects. In *C. rigidus* the funicle and second order stipes measure 1 to 2 mm in width, whereas in *C. flexilis* the same stipes measure but 0.4 mm in width.

Horizon.—*C. rigidus* was collected from zones 2 and 3, the lower and middle parts of the Marathon limestone (collections 11, 76, and 84). Raymond (1914) records the species from zone A of the Levis shale with *C. flexilis* and *T. approximatus* (an identical assemblage to that of zone 3 of the Marathon sequence). Harris and Thomas (1938b) report the species from the upper two zones of the Lancefield series in Victoria, Australia, with the same associates as in North America.

CLONOGRAPTUS cf. C. TENELLUS (Linnarson)

Pl. 4, figs. 1–3

Remarks.—The Texas specimens resemble *C. tenellus* in the extreme tenuity of the stipes and in general shape of the rhabdosome. However, the funicle length (1.5 mm) is less than that of Linnarson's types (Linnarson, 1871, Ofv. Kongl. Vet. Akad. Forh. Stockholm, vol. 28, p. 795, taf. 16, figs. 13–15). Also, the second order stipes are 2.0 to 2.2 mm in length whereas the same stipes of the type material are 3.8 to 4.0 mm in length. Only a few thecae of the Texas specimens are well preserved and they number 8 to 9 in 10 mm whereas those of the type number 9 to 10 in 10 mm. In shape of the thecae, the Texas specimens agree with the description of the type material. They are slender tubes, widening slightly toward their apertures, are inclined at 20 degrees to the stipe, and overlap for a small portion of their length.

Horizon.—The specimens tentatively referred to this species were collected from the lowest beds of the Marathon limestone, zone 1 (collections 72B and 119), where they are associated with anisograptids. Elles and Wood report the species *C. tenellus* is in the Tremadoc beds and the lower part of the Skiddaw slates in the British Isles.

CLONOGRAPTUS TENELLUS var. CALLAVEI (Lapworth)

?Bryograptus callavei Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, p. 165, pl. 5, fig. 21.
Clonograptus tenellus var. *callavei* Elles and Wood, 1902, Mon. British Grapt., p. 84, pl. 11, figs. 3a-c.

Remarks.—The Texas specimens have a well-developed web structure around the first and second order stipes, otherwise they agree with Elles and Wood's description. The variety is characterized by its short, wide stipes, which are much wider than in the typical *C. tenellus*.

Horizon.—A few specimens of this variety were collected from low in zone 2 (collection 84), in the lower part of the Marathon limestone. Elles and Wood record this variety from the Tremadoc, Shineton shales.

Genus TRIOGRAPTUS Monsen, 1925

TRIOGRAPTUS cf. T. OTAGOENSIS Benson and Keble

Pl. 4, fig. 7

Remarks.—The Texas specimens are poorly preserved and the details of the thecae cannot be clearly seen. However, the specimens agree with the description of *T. otagoensis* by Benson and Keble (1935, pp. 279–280, pl. 31, figs. 11–13) in having three straight stipes which enclose an angle of about 120 degrees and which rapidly attain a width of 0.5 to 0.7 mm and then maintain that width. Also, the thecae overlap about one-half their length and are inclined at a low angle (10 to 15 degrees) to the stipe. Further thecal details are obscure in the Texas specimens. In none of them do the stipes measure more than 5 mm, whereas Benson and Keble state that

in some of their forms the stipes attain a length of 20 mm. Although the Texas specimens are like *T. otagoensis* in gross aspect, they are referred to that species only tentatively because many details are obscured by the poor preservation.

Horizon.—The specimens referred to *T. otagoensis* were collected from the lower part of the Marathon limestone, zones 1 (collection 29) and 2 (collections 72D and 84). Benson and Keble record the species from New Zealand with an assemblage that is similar to that of zone 2 in the Marathon limestone.

Family PTILOGRAPTIDAE Hopkinson, 1875

Genus PTILOGRAPTUS Hall, 1865

PTILOGRAPTUS PLUMOSUS Hall

Pl. 7, fig. 6

Ptilograptus plumosus Hall, 1865, Canadian Organic Remains, p. 140, pl. 21, figs. 1–4.
Ptilograptus plumosus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 247, pl. 33, figs. 1–8.

Remarks.—The Texas specimens agree well with the specific description by Ruedemann.

Horizon.—Specimens of *P. plumosus* were collected from zone 4 of the upper part of the Marathon limestone (collection 121) and zone 9, the upper part of the Fort Peña formation (collection 28). Hall's types came from the Levis shale at Point Levis, Quebec, and Raymond (1914) lists it in his zone C-1, the lowest *Didymograptus* zone of the Levis shale. Ruedemann records the species from graptolite bed 7, zone of *Diplograptus dentatus*, of the Deepkill shale in New York. The species appears to have as long a range in eastern North America as it does in the Marathon region.

Order GRAPTOLOIDEA Lapworth, 1875

Family DICHOGRAPTIDAE Lapworth, 1873

Section GONIOGRAPTI

Genus GONIOGRAPTUS McCoy, 1876

GONIOGRAPTUS PERFLEXILIS Ruedemann

Goniograptus perflexilis Ruedemann, 1904, New York State Mus. Mem. 7, pp. 625–627, text figs. 39a-d, pl. 6, figs. 16–18, pl. 7, figs. 1–4, 6–9.
Goniograptus perflexilis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 297, pl. 48, figs. 10–15.

Remarks.—The Texas specimens agree well with Ruedemann's specific description.

Horizon.—A few specimens of *G. perflexilis* were collected from one locality (collection 47) which is in the highest beds of the Marathon limestone, zone 7. Ruedemann records the species as common in the upper part of the *Tetragraptus* horizon (graptolite zone 1) and as rare in the next higher horizon (zone of *Didymograptus bifidus*) of the Deepkill shale in New York. Raymond (1914) lists it from zones C-3 and D (zones of *D. bifidus* and *Diplograptus dentatus*) of the Levis shale in Quebec.

GONIOGRAPTUS THUREAUI (McCoy)

Pl. 8, fig. 15

Didymograptus (Goniograptus) thureaui McCoy, 1876, Ann. Mag. Nat. Hist., ser. 4, vol. 18, pp. 128–130.
Goniograptus thureaui Ruedemann, 1904, New York State Mus. Mem. 7, pp. 621–624, text figs. 37, 38, pl. 6, figs. 1–15.
Goniograptus thureaui var. *postremus* Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 295–296, pl. 48, figs. 2–9.

Remarks.—The Texas specimens agree fully with McCoy's specific description. The maximum number of stipes observed was 24, but some of the Australian forms have as many as 40. Ruedemann (1947) gave the varietal name *postremus* to forms with few stipes; however, McCoy's description does not set a limit on the number of stipes a form must have to be included in the species *G. thureaui*, and the Australian workers include forms with a few as well as many stipes in this species. Therefore, the writer includes Ruedemann's variety *postremus* with the typical form of the species.

Horizon.—A few specimens of *G. thureaui* were collected from one locality (collection 25) which is in the upper part of the Marathon limestone, zone 6. McCoy's types came from the Bendigo series in Victoria, Australia. Harris and Keble (1932) record the species as common in the zones of *Tetragraptus fruticosus* (three-branched form) and *T. fruticosus* (four-branched form) with *T. fruticosus* (three-branched

form), which are the middle part of the Bendigo series. Ruedemann states that his variety *postremus* is common in graptolite bed 2 (*Tetragraptus* zone) and that it extends into the next zone (*Didymograptus bifidus* zone) of the Deepkill shale in New York. Ruedemann also records it from the Levis shale in Quebec.

Genus BRACHIOGRAPTUS Harris and Keble, 1932

BRACHIOGRAPTUS ETAFORMIS Harris and Keble

Brachiograptus etaformis Harris and Keble, 1932, Royal Soc. Victoria, Proc. (n.s.), vol. 44, p. 44, pl. 6, figs. 8, 9.

Remarks.—The Texas specimens agree well with the specific description by Harris and Keble. Two forms figured by Ruedemann (1947, pl. 45, figs. 15, 16) as *Loganograptus logani* mut. *pertenuis* should be referred to *B. etaformis.*

Horizon.—A few specimens of *B. etaformis* were collected from one locality (collection 28) which is in the upper part of the Fort Peña formation, zone 9. Harris and Keble list the species from the middle part of the Middle Ordovician (zone of *Diplograptus decoratus*) in Victoria, Australia. Its associates in both the Victorian and Marathon successions include *Didymograptus nodosus, Trigonograptus ensiformis,* and *Cryptograptus schaferi.*

Genus LOGANOGRAPTUS Hall, 1868

LOGANOGRAPTUS LOGANI (Hall)

Graptolithus logani Hall, 1858, Geol. Survey of Canada, Rept. Prog. for 1857, p. 115.
Loganograptus logani Elles and Wood, 1902, Mon. British Grapt., pp. 81–82, pl. 11, figs. 1a-g.
Loganograptus logani Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 286–287, pl. 45, figs. 11–13, pl. 46, figs. 1, 2.

Remarks.—The Texas specimens agree with the description by Ruedemann except that the width of the first and second order stipes is 0.6 to 0.7 mm, whereas Ruedemann gives a width of 0.8 mm for the same stipes. The fourth order stipes widen from 0.7 mm at their origin to a maximum of 1.6 mm distally. The second order stipes of the Texas specimens are 1.3 to 1.4 mm in length, and in his description, Ruedemann states that the second order stipes "are about 1.4 mm long."

Horizon.—Ruedemann (*in* Sellards, 1933) first reported *L. logani* from the Marathon region. The writer collected it from the upper part of the Fort Peña formation, zone 9 (collections 13 and 28). Ruedemann records the species from graptolite bed 7 (zone of *Diplograptus dentatus*) of the Deepkill shale in New York, and Raymond (1914) lists it from his zone D-2 (zone of *D. dentatus*) of the Levis shale in Quebec. Elles and Wood describe *L. logani* from the Arenig, middle part of the Skiddaw slates in the British Isles. Harris and Keble (1932) list it among the characteristic forms of the highest zone (zone of *Isograptus caduceus* var. *maxima*) of the Castlemaine series in Victoria, Australia, and Harris (1935) lists it as very rare in the zone of *Glyptograptus intersitus* in the Middle Ordovician of the Victorian sequence.

LOGANOGRAPTUS LOGANI mut. PERTENUIS Ruedemann

Pl. 12, fig. 5

Loganograptus logani mut. *pertenuis* Ruedemann, 1904, New York State Mus. Mem. 7, p. 633, pl. 9, fig. 5.
Loganograptus logani mut. *pertenuis* Reudemann, 1947, Geol. Soc. America Mem. 19, p. 287, pl. 45, fig. 14 (not figs. 15, 16).

Remarks.—The Texas specimens agree well with Ruedemann's description. This variety is like the typical form of *L. logani* except that it is much thinner (0.2 to 0.3 mm in width compared to 0.7 to 0.8 mm in width). Also, the thecae number 10 to 12 in 10 mm in this variety while they number 8 to 10 in 10 mm in the typical form. Two forms figured by Ruedemann (1947, pl. 45, figs. 15, 16) do not belong to this variety but should be referred to *Brachiograptus etaformis.*

Horizon.—A few specimens of this thin variety of *L. logani* were collected from one locality (collection 28) which is in the upper part of the Fort Peña formation, zone 9. Ruedemann reports the variety to be rare in graptolite bed 7 of the Deepkill shale in New York.

Genus PTEROGRAPTUS Holm, 1881

PTEROGRAPTUS INCERTUS Harris and Thomas

Pl. 12, fig. 2

Pterograptus incertus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 289–290, fig. 1, nos. 1, 1a, fig. 2, nos. 1–6.

Remarks.—The Texas specimens agree well with the specific description by Harris and Thomas. Many of them are immature forms.

Horizon.—*P. incertus* was collected from the upper part of the Fort Peña formation, zone 9 (collections 16, 28, and 152). Harris and Thomas record it from the lower two zones (zones of *Glyptograptus austrodentatus* and *G. intersitus*) of the Middle Ordovician in Victoria, Australia. The species occurs with many of the same associates (*G. intersitus, Trigonograptus ensiformis,* and *Cryptograptus schaferi*) in both the Marathon and Victorian sequences.

Genus TRICHOGRAPTUS Nicholson, 1876

TRICHOGRAPTUS IMMOTUS Harris and Thomas

Trichograptus immotus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 290–291, fig. 1, nos. 2a-c, fig. 2, nos. 7, 8.

Remarks.—The Texas specimens agree well with the specific description by Harris and Thomas.

Horizon.—A few specimens of this species were collected from the upper part of the Fort Peña formation, zone 9 (collections 28 and 98). Harris and Thomas record it from the zone of *Diplograptus decoratus* in the Middle Ordovician of Victoria, Australia.

Section SCHIZOGRAPTI

Genus TROCHOGRAPTUS Holm, 1881

TROCHOGRAPTUS LAPWORTHI Ruedemann

Trochograptus lapworthi Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 294, pl. 47, figs. 18, 19.

Remarks.—The Texas specimens agree closely with Ruedemann's specific description.

Horizon.—Specimens of this species were collected from one locality (collection 48) which is in zone 4 of the Marathon limestone. Ruedemann's types came from the lowest zone of the Levis shale at Point Levis, Quebec. The species apparently occurs in slightly younger beds in the Levis sequence than it does in the Marathon.

Section DICHOGRAPTI

Genus DICHOGRAPTUS Salter, 1863

DICHOGRAPTUS OCTOBRACHIATUS (Hall)

Pl. 7, fig. 13; Pl. 8, figs. 2, 12

Graptolithus octobrachiatus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 122.
Dichograptus octobrachiatus Elles and Wood, 1902, Mon. British Grapt., pp. 77–79, pl. 9, pl. 10, figs. 1a-e.
Dichograptus octobrachiatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 288–289, pl. 46, figs. 3–7.

Remarks.—The Texas specimens agree well with the specific description by Ruedemann. The number of stipes that specimens of this species may have is not invariable, and septad and hexad types have been noted. One specimen of the hexad type was found in zone 6 (collection 23) in the Marathon limestone.

Horizon.—*D. octobrachiatus* is common in the upper part of the Marathon limestone, zones 3 (collection 80), 4 (collection 69), 5 (collection 26), and 6 (collections 23, 25, 114, and 115). Two specimens were found in the upper part of the Fort Peña formation, zone 9 (collection 28). Ruedemann states that the species is common in graptolite bed 2 (*Tetragraptus* zone), rare in graptolite bed 3 (*Didymograptus bifidus* zone), and one specimen was found in the uppermost horizon with *Diplograptus dentatus* of the Deepkill shale in New York. Elles and Wood record the species from the Arenig, Middle Skiddaw slates in England. The species ranges through the Bendigo series into the Chewton series in the Lower Ordovician of Victoria, Australia.

DICHOGRAPTUS MARATHONENSIS Berry, n. sp.

Pl. 13, fig. 5

Description.—Stipes of the first order are 2 mm long and thus the funicle is 4 mm long. The second order stipes are equal

in length to those of the first order and include an angle of 100 to 110 degrees. These give rise to stipes of the third order which are up to 2.5 cm long. The stipes of the first and second orders are about 0.4 mm wide but the third order stipes widen rapidly from 0.5 mm to 1.2 mm in width, which width is then maintained. Thecae appear only on the third order stipes and number 8 to 9 in 10 mm, are inclined at a 10- to 15-degree angle, are three times as long as they are wide, and overlap about one-third of their length.

Remarks.—This form is close to *D. norvegicus* Harris and Thomas (1940, p. 130; pl. 1, figs. 4a-c; pl. 2, fig. 5) but differs from it in having slightly longer first and second order stipes (2.0 mm compared to 1.5 mm in *D. norvegicus*) and the thecae show a constant angle of inclination to the stipe of 10 to 15 degrees, while in *D. norvegicus* the angle of inclination increases toward the aperture of the thecae.

Horizon.—This species is found in zone 9, the upper part of the Fort Peña formation (collections 14 and 28).

Holotype.—Yale Peabody Museum No. 20257.

Section TETRAGRAPTI

Genus TETRAGRAPTUS Salter, 1863

TETRAGRAPTUS ACCLINANS Keble

Pl. 7, fig. 5

Tetragraptus acclinans Keble, 1920, Rec. Geol. Surv. Victoria, vol. 4, p. 198, text fig. 63, pl. 33, figs. 2a-c.
Tetragraptus acclinans Harris and Thomas, 1938, Min. and Geol. Journal, p. 69, pl. 1, fig. 16.

Remarks.—The Texas specimens agree closely with Keble's specific description.

Horizon.—Specimens of this species were collected from zone 4 (collection 48) in the upper part of the Marathon limestone. Keble records it from the highest zone in the Lancefield series and the lowest zone of the Bendigo series in Victoria, Australia. The species occurs in the Marathon succession with the same associates (*T. fruticosus*, four-branched form, *Didymograptus extensus*, etc.) as it does in the Bendigo series in Australia.

TETRAGRAPTUS AMII Lapworth

Pl. 6, fig. 10; Pl. 7, fig. 9

Tetragraptus amii Lapworth MS, 1890.
Tetragraptus amii Elles and Wood, 1902, Mon. British Grapt., pp. 60–61, text fig. 36, pl. 5, figs. 4a-c.
Tetragraptus amii Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 301–302, pl. 50, figs. 12–14.

Remarks.—The Texas specimens are all small, but in shape of the rhabdosome, in number of thecae (10 in 10 mm) and in the character of the thecae, they agree with the description of *T. amii* by Elles and Wood. The main stipes of the Texas specimens are up to 2 cm in length and 2 mm in breadth, while Elles and Wood state that the main stipes are, as a rule, from 2.5 to 3.5 cm in length and 3 mm in width. They also state that a rapid increase in breadth near the initial extremity of the main stipes is characteristic and even the smaller forms which do not attain the maximum dimensions have this feature. The Texas forms do show this rapid increase in breadth at the proximal extremity of the main stipes. The sicula is obscure in all of the Texas specimens.

Horizon.—*T. amii* was collected from zones 4, 5, 6, of the upper part of the Marathon limestone (collections 26, 40, 69, and 71) and from low in zone 8 (collection 113) in the Alsate shale. Ruedemann found it in zone 2 (*Tetragraptus* zone) of the Deepkill shale in New York. Raymond (1914) lists it from his zone D-2 (*Diplograptus dentatus* zone) of the Levis shale of Quebec, and Miser and Purdue (1929) list it from the Mazarn shale in the Ouachita Mountains. Elles and Wood record the species from the Arenig, Middle Skiddaw slates in England.

TETRAGRAPTUS APPROXIMATUS (Nicholson)

Pl. 6, figs. 1–3

Tetragrapsus approximatus Nicholson, 1873, Ann. Mag. Nat. Hist., ser. 4, vol. 11, p. 136, fig. 2.
Tetragraptus approximatus Harris and Thomas, 1938, Min. and Geol. Jour., p. 74, pl. 1, figs. 17a-c, pl. 4, fig. 16.
Tetragraptus (Etagraptus) approximatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 312–313, pl. 52, figs. 4–6, 17, 18.

Remarks.—The Texas specimens agree closely with the specific description by Ruedemann. From specimen to specimen, the stipes show a slight variation in curvature at their origin from the funicle, but in all, the stipes become subparallel to one another. Because the stipes do show variation in curvature at their origin from the funicle, not all specimens form a perfect letter "H." Since Ruedemann gave the formation of a letter "H" by the second order stipes with the funicle as the distinctive character of the subgenus *Etagraptus*, the writer is of the opinion that the subgeneric category is not necessary, at least in the case of *T. approximatus*.

Horizon.—*T. approximatus* is the characteristic species of zone 3 (collections 76, 80, 120, and 130) in the middle part of the Marathon limestone. The species has been chosen as the name-giver to that zone. *T. approximatus* is common in Raymond's (1914) zone A, the lowest beds of the Levis shale in Quebec. Also, the species is the characteristic form in the highest zone of the Lancefield series of the Lower Ordovician in Victoria, Australia (Harris and Keble, 1932). It occurs in the Levis shale, in Marathon zone 3, and in the Lancefield zone 3, with the same associates (*Clonograptus rigidus, Tetragraptus quadribrachiatus,* etc.).

TETRAGRAPTUS BIGSBYI (Hall)

Pl. 7, fig. 11

Phyllograptus similis Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 140.
Graptolithus bigsbyi Hall, 1865, Canadian Organic Remains, p. 86, pl. 16, figs. 22–30.
Tetragraptus bigsbyi Elles and Wood, 1902, Mon. British Grapt., pp. 68–69, text figs. 42a, b, pl. 6, figs. 6a-e.
Tetragraptus similis Ruedemann, 1904, (pars) New York State Mus. Mem. 7, pp. 658–662, text figs. 58, 60, 61 (not fig. 59), p. 642, fig. 48, p. 644, fig. 49 (not fig. 50), pl. 12, figs. 3, 6, 9, 10, not figs. 2, 4, 5, 7.
Tetragraptus bigsbyi Monsen, 1937, Norsk, Geol. Tiddsskr., Bd. 16, pp. 169–170, taf. 4, figs. 1, 2, 6, 10, 24, taf. 13, figs. 7, 8, 10, 11.
Tetragraptus similis Ruedemann, 1947, (pars) Geol. Soc. America Mem. 19, p. 310, pl. 51, figs. 4, 5, 7, 11, not figs. 6, 8, 9, 10, 12, 13.

Remarks.—The Texas specimens agree well with Hall's original description and with Elles and Woods' figures and description. Hall (1858) originally placed these reclined tetragraptids under the genus *Phyllograptus* and gave them the specific name *similis*. Subsequently, Hall (1865) realized that such forms were not phyllograptids and removed them to the genus *Graptolithus*. Since he had already named a species *Graptolithus similis*, he gave the name *G. bigsbyi* to the forms originally called *P. similis*. Subsequently, the genus *Graptolithus* was split up to several genera including *Didymograptus* and *Tetragraptus*, and Hall's *G. similis* then became *D. similis*. Ruedemann (1904) stated that since *G. similis* was now *D. similis*, the name *Tetragraptus similis* would have priority over the name *T. bigsbyi* for the forms Hall originally named *Phyllograptus similis*. However, under the 1933 Rules of Nomenclature, Ruedemann was not correct in reviving a name which had been dropped. Other authors (Holm, 1895; Elles and Wood, 1902; Monsen, 1937; and Bulman, 1955) have followed Hall's (1865) usage, and this writer proposes to do so here. Further, Ruedemann (1904, pl. 12, figs. 2, 4, 5, and 7, and 1947, pl. 51, figs. 6, 8, 9, 10 12, and 13) included forms under *T. similis* not like Hall's description. These forms should be referred to the species *Tetragraptus serra*.

Horizon.—Specimens of *T. bigsbyi* were collected from the middle and upper parts of the Marathon limestone, zones 3 (collection 120), 4 (collection 71), 5 (collection 26), 6 (collections 25, 40, 52, 63, 64, and 115), and 7 (collection 47). Hall's original material came from the Levis shale in Quebec, and Raymond (1914) lists it from his zones C-2, C-3, and D-1 (*Didymograptus bifidus* and lower *Diplograptus dentatus* zones) of that shale. Ruedemann records the species from graptolite zone 1 (*Tetragraptus* zone) of the Deepkill shale in New York. Elles and Wood state that the species occurs in abundance in the lower part and ranges into the middle part of the Skiddaw slates (zones of *Didymograptus extensus* and *D. hirundo*) in the British Isles. Benson and Keble (1935) report the

form from New Zealand, and Harris and Keble (1932) show the species ranging through the Bendigo and Chewton series in Victoria, Australia. The species occurs in similar assemblages in both the Victorian and Marathon successions.

TETRAGRAPTUS DECIPIENS T. S. Hall

Pl. 5, fig. 4

Tetragraptus decipiens T. S. Hall, 1899, Royal Soc. Victoria, Proc. (n.s.), vol. 11, pp. 168–169, pl. 17, figs. 13–15, pl. 18, figs. 16–19.

Remarks.—The Texas specimens agree with T. S. Hall's specific description except that the outer margins of the thecae are straight, and the thecae maintain their low angle of inclination to the stipe throughout, while in the Australian material the outer margins of the thecae have a concave curvature which increases near the aperture.

Horizon.—Specimens of *T. decipiens* were collected from the lower part of the Marathon limestone, zone 2 (collections 72E and 84). Harris and Keble (1932) list *T. decipiens* with *Adelograptus victoriae* as characteristic species of the second zone in the Lancefield series of the Lower Ordovician in Victoria, Australia. *T. decipiens* occurs with the same associates in both the Victorian and Marathon sequences.

TETRAGRAPTUS DECIPIENS var. BIPATENS Keble and Harris

Tetragraptus decipiens var. *bipatens* Keble and Harris, 1934, Nat. Mus. Melbourne, Mem. 8, pp. 170–172, text figs. 2, 3.

Remarks.—The Texas specimens agree well with the specific description by Keble and Harris.

Horizon.—Specimens of this species were collected from one locality (collection 22) which is in zone 6 in the upper part of the Marathon limestone. Keble and Harris record the species from the lower part of the Bendigo series of the Australian Lower Ordovician. The species occurs slightly higher in the Marathon sequence than in the Victorian.

TETRAGRAPTUS FRUTICOSUS (Hall)

Pl. 6, figs. 7, 11, 12; Pl. 7, fig. 14; Pl. 8, figs. 1, 3; Pl. 9, fig. 3

Graptolithus fruticosus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 128.

Graptolites (Didymograptus) fruticosus McCoy, 1874, Geol. Survey Victoria, Prodr. Pal. Victoria, dec. 1, p. 13, pl. 1, figs. 9–14.

Tetragraptus fruticosus Elles and Wood, 1902, Mon. British Grapt., pp. 61–63, text fig. 37, pl. 6, figs. 2a, b.

Tetragraptus fruticosus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 304–305, pl. 51, figs. 25–32.

Remarks.—Two forms of this species are present in the Marathon succession. The two forms are alike in all essential characters except that in one, the normal four stipes are present, while in the other, one of the two secondary stipes does not develop, giving rise to a 3-branched form. Small 4-branched forms in which the stipes are rarely more than 15 mm in length appear first in the sequence, then larger 4-branched rhabdosomes in which the stipes are strongly curved and are up to 12 cm in length come in. The 3-branched rhabdosomes appear later than the small 4-branched forms but appear with the robust 4-branched forms. The 3-branched forms are not so robust as the large 4-branched forms, since their stipes measure only 3 to 4 cm in length and up to 3 mm in breadth.

Horizon.—*T. fruticosus* is a common species in the upper part of the Marathon limestone. The 4-branched form is the characteristic element of zone 4 (collections 4, 69, 71, and 101) and it ranges up into zones 5 (collections 26, 27, and 90) and 6 (collections 23, 114, and 115). The 3-branched form is the characteristic element of zone 5 (collections 26, 27, and 90), and it ranges into zone 6 (collections 23, 24F, 25, 40, 52, 63, 64, 65B, and 115) where it is very common. Ruedemann records the species from graptolite beds 1 and 2 (*Tetragraptus* zone) of the Deepkill shale in New York. Raymond (1914) lists it from his zone B of the Levis shale in Quebec. Elles and Wood report the species only from the Arenig rocks (zone of *Didymograptus extensus*) of the Girvan district

in South Scotland. The 4- and 3-branched varieties were among the first graptolites recognized in Australia (McCoy, 1874). Harris and Thomas (1938b) show that the subdivision of the Bendigo series in Victoria, Australia, is based on the introduction of the 4-branched form, then the appearance of the 3-branched form with the 4-branched form, and, finally, the loss of the 4-branched form with the 3-branched form remaining. The sequence of appearances of the two forms of this species is the same in both the Victorian and Marathon successions. Further, the species is associated with the same tetragraptids and didymograptids in both successions.

TETRAGRAPTUS PENDENS Elles

Pl. 7, fig. 7

Tetragraptus pendens Elles, 1898, Geol. Soc. London, Quart. Jour., vol. 54, p. 491, fig. 13.
Tetragraptus pendens Elles and Wood, 1902, Mon. British Grapt., pp. 63–64, text fig. 38, pl. 6, figs. 3a-d.
Tetragraptus pendens Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 306–307, pl. 51, figs. 18–21.

Remarks.—The Texas specimens of this characteristic slender species agree with Elles' description.

Horizon.—A few specimens of this species were collected from zone 4 of the Marathon limestone. They were identified in collection 71. Ruedemann recorded the species from the zone of *Didymograptus bifidus* of the Deepkill shale in New York and Raymond (1914) listed it from the same zone in the Levis shale in Quebec. Elles and Wood record it from the Arenig, Middle Skiddaw slates in England. Harris and Thomas (1938b) and Harris and Keble (1932) report *T. pendens* in the Bendigo series and ranging into the Chewton series in Victoria, Australia. The form appears slightly earlier (in the 4-branched *Tetragraptus fruticosus* zone) in Australia and in the Marathon region than it does in New York and Quebec.

TETRAGRAPTUS PYGMAEUS Ruedemann

Tetragraptus pygmaeus Ruedemann, 1904, New York State Mus. Mem. 7, pp. 664–665, pl. 12, figs. 11–14.
Tetragraptus pygmaeus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 307, pl. 51, figs. 14–17.

Remarks.—The Texas specimens agree well with Ruedemann's specific description.

Horizon.—Specimens of *T. pygmaeus* were obtained from zones 5 and 6 of the upper part of the Marathon limestone (collections 25, 40, and 90). Ruedemann states that this species is quite common in graptolite bed 2 (*Tetragraptus* zone) of the Deepkill shale in New York and is rare in beds with *Diplograptus dentatus* at Mt. Merino, New York.

TETRAGRAPTUS QUADRIBRACHIATUS (Hall)

Pl. 7, fig. 12

Graptolithus quadribrachiatus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 125.
Tetragraptus quadribrachiatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 307–308, pl. 50, figs. 15–18.

Remarks.—The Texas specimens agree fully with the description by Ruedemann.

Horizon.—This species has one of the longest ranges of any graptolite. Further, it is one of the earliest tetragraptids to appear and the last to drop out—ranging from zone 3 through zones 4, 5, 6, 7, 8, and into zone 9. It occurs in the upper part of the Marathon limestone, in the Alsate shale and in all but the highest beds of the Fort Peña formation and was identified in the following collections—13, 14, 15, 25, 26, 28, 30, 40, 40A, 47, 48, 52, 65B, 69, 71, 95, 98, 110, 111, 114, 120, and 121. Ruedemann records it from the *Tetragraptus* zone of the Deepkill shale and with *Diplograptus dentatus* near Mt. Merino, New York. Raymond (1914) lists it from zones A, B, and D-2 of the Levis shale in Quebec. Miser and Purdue (1929) list it from the Mazarn shale in the Ouachita Mountains. In Great Britain, the species occurs in the middle and upper beds of the Middle Skiddaw slates. Harris and Keble (1932) list the species as ranging from the highest zone of the Lancefieldian series (zone of *Tetragraptus approximatus*) through Bendigo, Chewton, and Yapeen series into the lower part of the Middle Ordovician of Victoria, Australia.

TETRAGRAPTUS RECLINATUS Elles and Wood

Tetragraptus reclinatus Elles and Wood, 1902, Mon. British Grapt., p. 67, text fig. 41, pl. 6, figs. 5a-e.

Remarks.—The Texas specimens agree well with Elles and Wood's specific description. *T. reclinatus* resembles *T. serra* in shape but can be easily distinguished because the stipes are much thinner (never more than 2.0 mm in *T. reclinatus* compared to 3.0 to 3.2 mm in *T. serra*) and the thecae more numerous per 10 mm (12 to 13 in *T. reclinatus* and 8 to 10 in 10 mm in *T. serra*).

Horizon.—Specimens of *T. reclinatus* were collected from zone 6 (collections 25 and 63) in the upper part of the Marathon limestone. Elles and Wood record the species from the Arenig, middle part of the Skiddaw slates. C. E. Decker (personal communication) found some poorly preserved specimens of the species in the West Spring Creek limestone of the Arbuckle group in the Arbuckle Mountains, Oklahoma.

TETRAGRAPTUS SERRA (Brongniart)

Pl. 6, fig. 6; Pl. 13, fig. 1

Fucoides serra Brongniart, 1828, Hist. Veget. Foss., p. 71, pl. 6, fig. 7, 8.
Tetragraptus serra Elles and Wood, 1902, Mon. British Grapt., pp. 65–67, text figs. 40a-c, pl. 6, figs. 4a-f.
Tetragraptus serra Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 309–310, pl. 50, figs. 19–23.

Remarks.—The Texas specimens are all immature but agree well with the specific description by Elles and Wood except that the thecae number 9 to 10 in 10 mm while they number 8 to 9 in 10 mm in the British material. However, in the figures of *T. serra* in the Elles and Wood monograph, the thecae number 9 to 10 in 10 mm near the proximal end, and this is the same region in which the thecal measurements were made on the Texas specimens.

Horizon.—Specimens of *T. serra* were collected from the upper part of the Marathon limestone, zones 5, 6, and 7 (collections 25, 26, 47, 52, and 63), and the middle part of the Fort Peña formation, zone 9 (collection 28). Brongniart's original material came from Point Levis, Quebec, and several authors cite the occurrence of this species there. Raymond (1914) lists it from his zones A, C-2, and D-2 of the Levis shale. Ruedemann records it from zone 1 (the *Tetragraptus* zone) of the Deepkill shale in New York. Elles and Wood report *T. serra* to be very abundant in the upper beds of the Arenig, Skiddaw slates where it occurs with *T. amii* and *Didymograptus extensus*. Harris and Thomas (1938b) figure *T. serra* as one of the most characteristic forms in the Bendigo series in Victoria, Australia. Harris and Keble (1932) show the species ranging through the Bendigo, Castlemaine, and what is now the Yapeen series in Victoria. *T. serra* has the same associated species and the same range in both the Marathon and Victorian sequences.

TETRAGRAPTUS TARAXACUM Ruedemann

Pl. 8, fig. 13

Tetragraptus taraxacum Ruedemann, 1902, New York State Mus. Bull. 52, p. 589, fig. 16.
Tetragraptus taraxacum Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 311, pl. 50, figs. 24–29.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description.

Horizon.—The specimens of *T. taraxacum* were collected from zones 3, 5, and 6 in the upper part of the Marathon limestone (collections 52, 64, 90, and 120). Ruedemann states that the majority of his specimens were obtained from graptolite bed 2 of the Deepkill shale (*Tetragraptus* zone) but a few were also observed in the beds with *Glytograptus dentatus* at Mt. Merino, New York.

Genus PHYLLOGRAPTUS Hall, 1858

PHYLLOGRAPTUS ANGUSTIFOLIUS Hall

Phyllograptus angustifolius Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 139.
Phyllograptus angustifolius Elles and Wood, 1902, Mon. British Grapt., pp. 100–101, text fig. 59, pl. 13, figs. 7a-f.
Phyllograptus angustifolius Ruedemann, 1947, Geol. Soc. America Mem. pp. 315–316, pl. 53, figs. 2–6.

Remarks.—The Texas specimens agree fully with the description by Elles and Wood.

Horizon.—This species was collected from zones 5 and 6 in the upper part of the Marathon limestone (collections 26, 40, 52, and 63). Ruedemann records the species from all three zones of the Deepkill shale in New York. Hall's types came from the Levis shale in Quebec. Elles and Wood state that *P. angustifolius* is an abundant form in the Skiddaw slates where it has a fairly long range. Harris and Thomas (1938b) include it as a common species in the Bendigo series in Victoria, Australia.

PHYLLOGRAPTUS ANNA Hall

Pl. 8, fig. 14; Pl. 10, fig. 4

Phyllograptus anna Hall, 1865, Canadian Organic Remains, p. 124, pl. 16, figs. 11–16.
Phyllograptus anna Elles and Wood, 1902, Mon. British Grapt., pp. 101–102, text figs. 60a-b, pl. 13, figs. 6a-f.
Phyllograptus anna Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 316–317, pl. 53, figs. 27–32.

Remarks.—The Texas specimens agree fully with the description by Ruedemann.

Horizon. — Ruedemann (*in* Sellards, 1933) first reported *P. anna* from the Marathon limestone. The writer collected it from zones 5, 6, and 7 in the upper part of that formation (collections 20, 23, 25, 26, 40A, 47, 52, 63, 65A, 65C, 67, and 115). Ruedemann records the species from the "last layers of graptolite bed 2" (*Tetragraptus* zone), throughout the horizon with *Didymograptus bifidus* (zone 2), and from zone 3 bed 1 (zone of *Diplograptus dentatus*) of the Deepkill shale in New York. Raymond (1914) listed the species from zone C-3 (zone of *D. bifidus*) of the Levis shale in Quebec. Elles and Wood report it from the middle part of the Skiddaw slates in the British Isles.

PHYLLOGRAPTUS ANNA mut. LONGUS Ruedemann

Pl. 8, fig. 16

Phyllograptus anna Hall mut. *longus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 317, pl. 53, figs. 36–40.

Remarks.—The Texas specimens agree closely with Ruedemann's description.

Horizon.—Specimens of this variety were collected from one locality (collection 25) which is in zone 6 in the upper part of the Marathon limestone. Ruedemann's type material came from the Glenogle shale in British Columbia.

PHYLLOGRAPTUS ILICIFOLIUS Hall

Pl. 8, fig. 4; Pl. 9, figs. 1, 2

Phyllograptus ilicifolius Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 139.
Phyllograptus ilicifolius Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 317–318, pl. 53, figs. 9–19.

Remarks.—The Texas specimens agree fully with the specific description by Ruedemann.

Horizon.—*P. ilicifolius* is a common fossil in zones 4 (collection 71), 5 (collection 26), 6 (collections 23, 25, 30, 40, 40A, 52, and 115), and 7 (collections 19 and 20) in the upper part of the Marathon limestone. The species is very common in zone 1 (*Tetragraptus* zone) bed 2 and rare in zone 1 bed 1 and in zone 2 (*Didymograptus bifidus* zone) of the Deepkill shale in New York. Raymond (1914) lists it from his zones A, C-1, C-2, and C-3 of the Levis shale in Quebec. Ruedemann records it from many other localities in North America, and Harris and Thomas (1938b) figure it as one of the characteristic species in the Bendigo series in Victoria, Australia.

PHYLLOGRAPTUS NOBILIS Harris and Keble

Pl. 14, figs. 6, 7

Phyllograptus nobilis Harris and Keble, 1932, Royal Soc. Victoria, Proc. (n.s.), vol. 44, p. 41, pl. 6, figs. 3, 4.

Remarks.—The Texas specimens agree fully with the specific description by Harris and Keble.

Horizon.—Specimens of *P. nobilis* were collected from but one locality (collection 85) which is in the highest beds of the Fort Peña formation, zone 10. Harris and Keble's type specimens came from the upper part of the Middle Ordovician in Victoria, Australia, and Harris (1935) lists the species as very common in the zone of *Diplograptus (Mesograptus) decoratus*

of the Middle Ordovician of the Victorian sequence.

PHYLLOGRAPTUS TYPUS Hall

Pl. 10, figs. 1, 11, 13

Phyllograptus typus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 137.
Phyllograptus cf. *typus* Elles and Wood, 1902, Mon. British Crapt., pp. 99–100, text fig. 58, pl. 13, figs. 5a, b.
Phyllograptus typus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 320–321, pl. 53, figs. 22–26.

Remarks.—Rhabdosomes of this species are highly variable in length and width. The British forms are slightly larger than the American types described by Hall. The British specimens vary in form from long and narrow with maximum dimensions of 57 mm in length and 6.3 mm in width to shorter and broader forms with dimensions of 25.4 mm in length and 8.7 mm in width. Ruedemann states that the American material does not reach these extremes in dimensions, but one form figured by Hall measures 56 mm in length and 17 mm in width, and a specimen from the Levis shale figured by Ruedemann measures 55 mm in length and 17 mm in width. The specimens from the Marathon region were measured, and the size range was from forms 15 mm in length and 0.9 mm in width to forms 35 mm in length and 16 mm in width. The mean length of the specimens was 20.4 mm and the mean width 10.1 mm. The Texas specimens are shorter and broader than the British material, but they compare favorably in form ratio with specimens from the Deepkill shale in New York. In the curved character of the thecae, in the number of thecae (9 to 10 per 10 mm), and in the slightly mucronate apertures, the Texas specimens agree with the specific description by Ruedemann.

Horizon.—Ruedemann (1947, p. 321) states that he had "undoubted specimens of this species" from the Marathon region. The writer collected it from the upper part of the Marathon limestone, zones 6 and 7 (collections 47, 63, 65C, 65D, 67, and 70) and from the Alsate shale and lower part of the Fort Peña formation, zone 8 (collections 113 and 141). The species is common in zone 7 but is rare in the zones above and below. Ruedemann records the species from graptolite bed 3 (zone of *Didymograptus bifidus*) of the Deepkill shale in New York. Raymond (1914) lists it from zone B of the Levis shale in Quebec. Ruedemann also records it from the Glenogle shale in British Columbia associated with a fauna similar to that of zone 8 in the Marathon succession. The forms Elles and Wood referred to *P. typus* came from the Arenig, Middle Skiddaw slates in Scotland and Wales. Harris and Thomas (1938b) figure a form tentatively referred to *P. typus* as a characteristic element of the fauna of the Castlemaine series in Victoria, Australia.

Section DIDYMOGRAPTI

Genus DIDYMOGRAPTUS McCoy (in Sedgwick and McCoy, 1851)

DIDYMOGRAPTUS AFFINIS (Nicholson)

Didymograpsus affinis Nicholson, 1869, Ann. Mag. Nat. Hist., ser. 4, vol. 4, p. 240, pl. 11, fig. 20.
Didymograptus affinis Elles and Wood, 1901, Mon. British Grapt., pp. 23–24, text figs. 13a, 13b, pl. 2, figs. 1a-b.

Remarks.—The stipes of the Texas specimens are not more than 0.5 mm wide and diverge at an angle of 160 degrees from the sicula, whereas in the British specimens the stipes are 0.6 mm wide and diverge at an angle of 90 to 150 degrees. In all other respects the Texas specimens agree with the description of the British material by Elles and Wood.

Horizon.—*D. affinis* was collected from the Alsate shale (collections 8 and 113) in the lower part of zone 8. The species has been recorded from the Glenogle shale (Ruedemann, 1947) and from the Arenig, middle and upper part of the Skiddaw slates in the British Isles.

DIDYMOGRAPTUS ARTUS Elles and Wood

Pl. 10, figs. 2, 5, 6

Didymograptus artus Elles and Wood, 1901, Mon. British Grapt., p. 48, text fig. 30, pl. 4, figs. 6a-d.
Didymograptus artus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 326, pl. 54, figs. 3–10.

Remarks.—The Texas specimens agree well with Elles and Wood's description.

Horizon.—*D. artus* is a diagnostic species of zone 7, the highest in the Marathon limestone, and it is restricted to that zone. It was identified in collections 19, 24A, 24B, and 47. Ruedemann (1947) records the species from the Black Rock limestone in Arkansas and the Joins limestone in the Arbuckle Mountains in Oklahoma. Elles and Wood report the species in the upper part of the Skiddaw slates where it is a diagnostic form of the zone of *Didymograptus bifidus*. The species has not been reported from Australia; its appearance in the Marathon succession with a predominantly Australian graptolite sequence affords a tie point between the British and Australian zonal schemes.

DIDYMOGRAPTUS BIFIDUS (Hall)

Pl. 10, figs. 3, 7–10

Graptolithus bifidus Hall, 1865, Canadian Organic Remains, p. 73, pl. 1, figs. 16–18, pl. 3, figs. 9–10.
Didymograptus bifidus Elles and Wood, 1902, Mon. British Grapt., pp. 42–44, text figs. 26a, b, pl. 4, figs. 1a-f.
Didymograptus bifidus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 327–328, pl. 54, figs. 11–16.

Remarks.—The Texas specimens are all small, and although numerous specimens were collected from several localities, many are immature. The character and number of the thecae, the size of the sicula, and the variation in angle of divergence of the stipes agree with the description given by Ruedemann. The length of the mature forms ranges from 1.2 to 2.2 cm and the width from 2.0 to 2.4 mm. Although none of the Texas specimens attained the dimensions of Hall's largest forms, some do fall within the range of variation of the dimensions given by both Elles and Wood and by Ruedemann; therefore some specimens of adult forms of *D. bifidus* appear to be present.

Associated with *D. bifidus* in the lower part of zone 7 are several transient forms between *D. bifidus* and *D. protobifidus* which are very close to *D. bifidus*. The transients have thinner stipes and fewer thecae per 10 mm than the true *D. bifidus*.

Horizon.—Ruedemann (*in* Sellards, 1933) first recorded *D. bifidus* from the Marathon limestone. It is the most diagnostic fossil of zone 7, the uppermost 30 feet of the Marathon limestone. The species is common and widespread in the zone, and it was identified in the following collections: 9, 19, 20, 24A and B, 47, 65D, 67, and 70. *D. bifidus* is the characteristic element of zone 2 of the Deepkill shale in New York and of Raymond's (1914) zones C-2 and C-3 of the Levis shale in Quebec. The species is widely distributed in the lower part of the Llanvirn series in the British Isles, and it marks the sixth zone of the British sequence.

DIDYMOGRAPTUS COMPRESSUS Harris and Thomas

Didymograptus compressus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 293–294, fig. 1, nos. 6a-c, fig. 2, nos. 20, 21.

Remarks.—The Texas specimens agree closely with the specific description by Harris and Thomas.

Horizon.—Specimens of this species were collected from the upper part of the Fort Peña formation, zone 9 (collection 28). Harris and Thomas (1935) report the species to be common in the zone of *Glyptograptus intersitus* and to be rare in the zone below (zone of *Glyptograptus austrodentatus*) in the Middle Ordovician of Victoria, Australia. *D. compressus* occurs with the same associates (*G. intersitus, G. austrodentatus, Trigonograptus ensiformis, Didymograptus nodosus*, etc.) in both the Marathon and Victorian sequences.

DIDYMOGRAPTUS CUSPIDATUS Ruedemann

Didymograptus cuspidatus Ruedemann, 1904, New York State Mus. Mem. 7, p. 698, text fig. 90, pl. 15, figs. 8, 9.
Didymograptus cuspidatus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, p. 293, fig. 1, no. 9, fig. 2, nos. 11, 12.
Didymograptus cuspidatus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 330, pl. 55, fig. 2, pl. 56, fig. 19.

Remarks.—The sicula is short and inconspicuous, and the stipes originate sub-

orally from it at different levels and diverge initially at an angle of 140 to 160 degrees, but later they become sub-horizontal. The stipes are 2.0 cm or more long and are narrow (0.4 mm) at first but widen to 1.0 mm. The thecae number 12 to 13 in 10 mm and the mature ones overlap about one-third their length. The inclination of the early thecae is about 20 degrees but increases to 40 degrees in the apertural part of the later thecae. The apertural margins are slightly convex and approximately normal to the axis of the stipe.

The above description of the Texas specimens agrees well with Ruedemann's description based on a single specimen.

Horizon.—*D. cuspidatus* was collected from the Fort Peña formation, zones 8 (collection 61B) and 9 (collections 14, 16, and 98). Ruedemann's type came from the shales with *Diplograptus dentatus* at Mt. Merino, New York. Harris and Thomas record it from the zone of *Diplograptus decoratus* of the Middle Ordovician in Victoria, Australia. The species occurs with the same associates (*Hallograptus etheridgei, Cryptograptus schaferi,* and *Didymograptus nodosus*) in both the Marathon and Victorian sequences.

DIDYMOGRAPTUS DENTICULATUS Berry, n. sp.

Pl. 10, fig. 12

Description.—The stipes diverge initially at about a 90-degree angle, then incurve and become subparallel. They widen from 0.8 to 1.5 mm in the first 5 mm, then increase in width gradually to a maximum of 1.8 mm. The stipes are 1.7 cm in length. The thecae number 7 in 10 mm, overlap one-half their length, are three times as long as they are wide, and are inclined at a 35- to 45-degree angle to the stipe. The apertural margins are concave and have distinct mucros.

Horizon.—Specimens of this species were collected from one locality only (collection 20), which is in the uppermost part of the Marathon limestone, zone 7.

Holotype.—Yale Peabody Museum No. 20252.

DIDYMOGRAPTUS ELLESAE Ruedemann

Didymograptus ellesi Ruedemann, 1904, New York State Mus. Mem. 7, pp. 682–683, text figs. 75, 76, pl. 14, figs. 22–24.
Didymograptus ellesae Ruedemann, 1908, New York State Mus. Mem. 11, p. 134.
Didymograptus ellesae Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 330–331, pl. 55, figs. 8–10, pl. 56, fig. 15.

Remarks.—The Texas specimens agree closely with Ruedemann's description.

Horizon.—Specimens of this species were collected from one locality (collection 48) where they were associated with *Didymograptus extensus, Tetragraptus acclinans,* and *Tetragraptus quadribrachiatus.* The locality is in zone 4, in the upper part of the Marathon limestone. Ruedemann obtained his type material from graptolite bed 3 (*D. bifidus* zone) of the Deepkill shale in New York.

DIDYMOGRAPTUS EUODUS Lapworth

Didymograptus euodus Lapworth, 1875, Geol. Soc. London, Quart. Jour., vol. 31, p. 645, pl. 35, figs. 1a-c.
Didymograptus euodus Elles and Wood, 1901, Mon. British Grapt., pp. 21–22, text fig. 12, pl. 1, figs. 10a-b.
Didymograptus euodus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 332–333, pl. 55, figs. 33–36, pl. 56, figs. 22–24.

Remarks.—The Texas specimens agree with the description by Elles and Wood except that the stipes attain a width of 2.2 mm while the British specimens are 2.4 mm in width.

Horizon.—*D. euodus* was collected from the lower part of the Fort Peña formation, zone 8 (collection 110). Ruedemann has recorded the species from the Blakely sandstone in the Ouachita Mountains in Arkansas and the upper part of the Glenogle shale in British Columbia. Elles and Wood state that the species is known in the British Isles only from the zone of *Didymograptus murchisoni* in the Llanvirn series.

DIDYMOGRAPTUS EXTENSUS (Hall)

Pl. 6, fig. 5; Pl. 8, fig. 10

Graptolithus extensus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 132.
Didymograptus extensus Elles and Wood, 1901, Mon. British Grapt., pp. 8–9, text figs. 4a-d, pl. 1, figs. 1a, b.

Didymograptus extensus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 331–332, pl. 55, fig. 16, pl. 56, figs. 1, 2.

Remarks.—The Texas specimens agree well with the specific description by Ruedemann.

Horizon.—*D. extensus* is a common species in zones 3, 4, 5, and 6 (collections 21, 23, 25, 26, 27, 32, 40, 48, 52, 65C, 66, 79, 90, 91, and 115), ranging from the middle of the Marathon limestone to near the top of it. Hall obtained the type material from the Levis shale in Quebec, and Raymond (1914) lists it in his zone C-2 of that formation. Ruedemann found it in bed 2 (*Tetragraptus* zone) of the Deepkill shale and Elles and Wood record it from the middle part of the Skiddaw slates of the Lake District and several other localities. Harris and Keble (1932) show the species ranges from the upper part of the Bendigo series, zone of *Tetragraptus fruticosus* (3- and 4-branched forms) through the Chewton series in Victoria, Australia.

DIDYMOGRAPTUS LEPTOGRAPTOIDES Monsen

Didymograptus leptograptoides Monsen, 1937, Norsk. Geol. Tidsskr., Bd. 16, pp. 136–138, taf. 2, figs. 3, 4, 32, 57, 63, 67, taf. 9, fig. 2.

Remarks.—The Texas specimens agree closely with Monsen's specific description.

Horizon.—The specimens of *D. leptograptoides* were collected from one locality only (collection 115) which is in zone 6 in the upper part of the Marathon limestone. Monsen's types came from the zone of *Phyllograptus densus* of the lower *Didymograptus* shales in Norway.

DIDYMOGRAPTUS MENDICUS Keble and Harris

Pl. 11, fig. 3

Didymograptus mendicus Keble and Harris, 1934, Nat. Mus. Melbourne Mem. 8, pp. 168–169, pl. 20, fig. 2.

Remarks.—The Texas specimens agree fully with the specific description by Keble and Harris.

Horizon.—Specimens of *D. mendicus* were collected from the Alsate shale (collection 113) which is the lower part of zone 8. Keble and Harris record the species from beds now included in the Chewton series in Victoria, Australia.

DIDYMOGRAPTUS NICHOLSONI Lapworth

Didymograptus nicholsoni Lapworth, 1875, Geol. Soc. London, Quart. Jour., vol. 31, p. 644, pl. 33, figs. 5a-d.

Didymograptus nicholsoni Elles and Wood, 1901, Mon. British Grapt., pp. 27–28, text figs. 16a-c, pl. 2, figs. 4a-c.

Didymograptus nicholsoni Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 338–339, pl. 55, figs. 26–28, pl. 56, fig. 7.

Remarks.—The Texas specimens agree fully with the specific description by Elles and Wood.

Horizon.—Ruedemann (*in* Sellards, 1933) first listed *D. nicholsoni* from the Marathon limestone. The writer collected specimens of the species from zones 4, 5, and 6 of the upper part of the Marathon limestone (collections 39, 66, 68, and 115). Ruedemann records the species from Newfoundland as well as Marathon, Texas. Elles and Wood report it to be present in the middle and upper parts of the Skiddaw slates and to range into the zone of *D. bifidus* (low Llanvirn). Harris (1935) listed *D. nicholsoni* from the Bendigo series in Victoria, Australia.

DIDYMOGRAPTUS NICHOLSONI var. PLANUS Elles and Wood

Didymograptus nicholsoni var. *planus* Elles and Wood, 1901, Mon. British Grapt., p. 29, text figs. 17a, b, pl. 2, figs. 5a, b.

Didymograptus nicholsoni var. *planus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 339, pl. 55, figs. 23–25, pl. 56, figs. 8, 9.

Remarks.—The Texas specimens agree closely with Elles and Wood's description.

Horizon.—A few specimens only of this variety were collected from zones 4 and 5 in the upper part of the Marathon limestone (collections 26, 69, and 90). Ruedemann records the variety from zone 1 (the *Tetragraptus* zone) of the Deepkill shale in New York and from the Glenogle shale in British Columbia. Elles and Wood's type specimens came from the upper part of the Skiddaw slates.

DIDYMOGRAPTUS NITIDUS (Hall)

Pl. 8, fig. 11

Graptolithus nitidus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 129.

Didymograptus nitidus Elles and Wood, 1901, Mon. British Grapt., pp. 10–11, text fig. 5a-d, pl. 1, figs. 2a-e.
Didymograptus nitidus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 339–340, pl. 55, figs. 11–14, pl. 56, fig. 21.

Remarks.—The Texas specimens agree closely with the specific description by Ruedemann.

Horizon.—Ruedemann (*in* Sellards, 1933) first listed *D. nitidus* from the Marathon limestone. The writer collected specimens of the species from several localities in zones 3, 4, 5, and 6 of the middle and upper parts of the Marathon limestone (collections 26, 36, 39, 66, 68, 69, 71, 79, 90, 91, and 101). Ruedemann found the species in graptolite beds 1 and 2 (*Tetragraptus* zone) of the Deepkill shale in New York. Raymond (1914) lists it from zone C-1 of the Levis shale in Quebec and Miser and Purdue (1929) list it from the Mazarn shale in the Ouachita Mountains in Arkansas. Elles and Wood state that the form is widely distributed in the middle part of the Skiddaw slates in the British Isles, and Harris and Keble (1932) show it ranges through the Bendigo and beds now placed in the Chewton series in Victoria, Australia.

DIDYMOGRAPTUS NODOSUS Harris

Pl. 12, fig. 3

Didymograptus nodosus Harris, 1926, Royal Soc. Victoria, Proc. (n.s.), vol. 38, p. 56, pl. 1, figs. 1–4.
Didymograptus nodosus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, p. 295, fig. 2, no. 27.

Remarks.—The Texas specimens of this species are poorly preserved, but they agree in all characters with the specific description by Harris (1926). The species is characterized by distinctive thecae which are curved tubes arranged so that each arises from the preceding theca about halfway along its dorsal margin, then runs parallel with that theca and continues beyond its aperture. The apertural margins are straight and make an acute angle with the axis of the stipe. The stipes are marked by small trumpet-shaped promontories which are formed by the aperture of one theca and the heel of its successor. The Texas specimens do not show the thecal spines which Harris and Thomas (1935) described on some specimens of this species.

Horizon.—Specimens of *D. nodosus* were collected from the upper part of the Fort Peña formation, zone 9 (collections 16, 28, 98, and 152). Harris (1935) records the species as very common in the zone of *Diplograptus decoratus* in the upper part of the Middle Ordovician of Victoria, Australia. Its associates in both the Marathon and Australian sequences include *Cryptograptus schaferi, Trigonograptus ensiformis,* and *Isograptus forcipiformis.*

DIDYMOGRAPTUS NOVUS Berry, n. sp.

Pl. 5, fig. 6, 7

Description.—The stipes are a maximum of 6 mm in length. They widen rapidly to a width of 0.4 mm and maintain that width throughout. The sicula is suspended from a fairly long nema (2 to 3 mm in length) and is about 0.8 mm in length. The stipes diverge from it at about a 180-degree angle and remain straight for the greater part of their length but curve slightly upward at their distal ends. The thecae number 5 to 6 in 5 mm, are four times as long as they are wide, overlap one-half to two-thirds their length, and are inclined at an angle of 25 to 30 degrees to the stipe. The apertural margins are straight and are inclined at an angle of 100 to 105 degrees to the stipe. This form resembles *D. serpens* (Monsen, 1937, p. 131) but differs from it in the larger angle of divergence of the stipes, in the shorter length of the stipes, in the shorter sicula, and in the slightly higher angle of inclination of the thecae to the stipe.

Horizon.—Specimens of this species were collected from the lower part of the Marathon limestone, zone 2 (collections 72C, 72D, and 72E). This is the earliest didymograptid to occur in the Marathon succession.

Holotype.—Yale Peabody Museum No. 20254.

DIDYMOGRAPTUS PACIFICUS Ruedemann

Pl. 11, fig. 4

Didymograptus pacificus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 340–341, pl. 54, figs. 30–32.

Remarks.—The Texas specimens agree well with Ruedemann's specific description.

Horizon.—Specimens of *D. pacificus* were collected from the lower part of the Fort Peña formation, zone 8 (collections 107 and 140). Ruedemann's types of the species came from the Sarback formation on Fossil Mountain 8.7 miles northeast of the Lake Louise Station on the Canadian Pacific Railway, Alberta, Canada.

DIDYMOGRAPTUS PARAINDENTUS Berry, n. sp.

Pl. 11, figs. 1, 2

Description.—The stipes diverge from the sicula at an initial angle of 60 degrees then incurve and become subparallel. They widen rapidly to a maximum of 1 mm and maintain that width throughout and are a maximum of 1.2 cm in length. The sicula is 1.5 mm in length, 0.6 mm in width at its base, and tapers rapidly towards its apex. The thecae number 12 to 14 in 10 mm, are three times as long as they are wide, overlap about one-half their length, and are inclined at a 25- to 30-degree angle to the stipe. The apertural margins are slightly concave and small mucros are present. This form resembles *D. indentus* but differs from it in having more closely set thecae and a much shorter sicula.

Horizon.—Specimens of this species were collected from the lower part of the Fort Peña formation, zone 8 (collections 61A and 141).

Holotype.—Yale Peabody Museum No. 20253.

DIDYMOGRAPTUS PATULUS (Hall)

Pl. 6, fig. 9; Pl. 7, fig. 8

Graptolithus patulus Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 131.
Didymograptus patulus Elles and Wood, 1901, Mon. British Grapt., pp. 13–14, text figs. 8a, b, pl. 1, figs. 8a-c.
Didymograptus patulus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 341–342, pl. 55, figs. 17–22, pl. 56, figs. 16, 17.

Remarks.—The Texas specimens agree fully with the description given by Ruedemann. *D. patulus* is quite similar to *D. nitidus*, but the forms identified by the writer as *D. patulus* have wider and more rapidly widening branches and more inclined and curved thecae that are less closely arranged than in *D. nitidus*.

Horizon.—*D. patulus* was first reported in the Marathon limestone by Ruedemann (*in* Sellards, 1933). The writer collected the species from zones 4, 5, and 6 of the upper part of the Marathon limestone, where it is abundant (collections 23, 25, 26, 32, 68, 69, 91, 102, and 115). *D. patulus* is common in the horizons characterized by Tetragrapti and Didymograpti but does not persist to the zone of *D. bifidus*. In New York, Ruedemann records the species as common in zone 1 (*Tetragraptus* zone) of the Deepkill shale. Hall's type material came from the Levis shale in Quebec. Gurley (1896) lists it from the main *Tetragraptus* zone but Raymond (1914) did not mention it. *D. patulus* occurs in England in the middle and upper Arenig in Shropshire and in the lower Llanvirn of St. David's district in Wales associated with *D. bifidus, D. artus,* and *D. nicholsoni. D. patulus* ranges into a somewhat higher horizon in England than in Texas.

DIDYMOGRAPTUS PROTOBIFIDUS Elles

Pl. 8, figs. 5–9

Didymograptus protobifidus Elles, 1933, Geol. Survey Great Britain, Summ. Prog. for 1932, p. 98, figs. 1–3.
Didymograptus protobifidus Ripper, 1937, Royal Soc. Victoria, Proc. (n.s.), vol. 49, pp. 154–156, text fig. 1.
Didymograptus protobifidus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 343–344, pl. 54, fig. 18.

Remarks.—There appears to be considerable variation in the forms referred to *D. protobifidus* by various workers. However, the Texas specimens clearly fall within the range in variation in the species as delimited by Elles. The rhabdosomes of the Texas specimens are small. The stipes range from 1 to 2 cm in length and are 0.5

to 0.7 mm wide at their origin and increase to a maximum of 1.3 mm distally. They diverge initially at about 90 degrees but soon curve so that they become subparallel. The thecae number 12 to 14 in 10 mm, are free one-half their length, are inclined at a low, variable angle (20 to 45 degrees) to the axis of the stipe, and are slightly curved distally with apertural margins slightly oblique to the axis of the stipe.

Horizon.—*D. protobifidus* is the most characteristic element of zone 6 in the upper part of the Marathon limestone and gives its name to that zone. The species is very common in the zone (collections 23, 24F, 25, 30, 40, 40A, 52, 64, and 115) and is confined to it. Ruedemann records the species from the West Spring Creek limestone of the Arbuckle group in the Arbuckle Mountains, Oklahoma, and from the limestone near Smithville, Arkansas. The writer has collected specimens of the species from the Deepkill shale in New York. *D. protobifidus* is found in the British Isles in the middle and upper parts of the Skiddaw slates in the zones of *D. extensus* and *D. hirundo*. In Australia, *D. protobifidus* is the characteristic element in the faunas of the lower two zones of the Chewton series of the Lower Ordovician. The species occurs in the British, Marathon, and Victorian sequences with extensiform Didymograpti, several species of *Tetragraptus* including *Tetragraptus fruticosus*, and Phyllograpti.

DIDYMOGRAPTUS PROTOINDENTUS Monsen

Didymograptus protoindentus Monsen, 1937, Norsk. Geol. Tidsskr., Bd. 16, pp. 148–149, taf. 2, figs. 40, 46, 47, 54, taf. 5, fig. 1, taf. 10, figs. 16, 17.

Remarks.—The Texas specimens agree closely with Monsen's specific description.

Horizon.—Specimens of *D. protoindentus* were collected from one locality only (collection 20), which is in zone 7, the highest beds of the Marathon limestone. Monsen's types came from the zone of *Phyllograptus densus* of the lower *Didymograptus* shales in Norway.

DIDYMOGRAPTUS SAGITTICAULIS Gurley

Didymograptus sagitticaulis Gurley, 1896, Jour. Geol., vol. 4, p. 68.
Didymograptus sagitticaulis Ruedemann, 1908, New York State Mus. Mem. 11, pp. 248–251, text figs. 151–155, pl. 14, fig. 3.
Didymograptus sagitticaulis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 344–345, pl. 55, figs. 3–5, pl. 56, figs. 12–14.

Remarks.—The Texas specimens agree well with Ruedemann's specific description except that the thecae number 6 to 10 at the proximal end of the stipes, whereas the thecae number 7 in 10 mm in the same part of the stipe in the type material.

Horizon.—*D. sagitticaulis* was collected from zone 12, the upper part of the Woods Hollow shale (collections 94A and 94C). The types of the species were collected from the Normanskill shale near Albany, New York, and the species has been reported in the Normanskill shale at several other localities. Ruedemann also reports the species from the Glenogle shale in British Columbia and the Womble shale in Arkansas. Decker (1952) lists it from several localities of the "Athens" shale in Virginia and Tennessee.

DIDYMOGRAPTUS SERRATULUS (Hall)

Graptolithus serratulus Hall, 1847, Paleontology of New York, vol. 1, p. 274, pl. 74, figs. 5a-b.
Didymograptus serratulus Elles and Wood, 1901, Mon. British Grapt., pp. 29–30, text figs. 18a, b, pl. 2, figs. 7a, b.
Didymograptus serratulus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 346–347, pl. 54, figs. 49–51.

Remarks.—The Texas specimens are poorly preserved, but they appear to agree with the description given by Ruedemann.

Horizon.—Specimens of *D. serratulus* were obtained from zones 11 and 12, the upper part of the Woods Hollow shale (collections 94A, 100, 104, 105, and 127). Ruedemann's types of this species came from the Normanskill shale at Kenwood, New York. The species has been recorded from other localities in the Normanskill shale and from the Stringtown shale in Oklahoma and the Womble shale in Arkansas. Elles and Wood report the species in the Glenkiln shales of South Scotland

and Etheridge (1878) listed the species in his catalogue of Australian fossils.

DIDYMOGRAPTUS SIMILIS (Hall)

Graptolithus similis Hall, 1865, Canadian Organic Remains, p. 78, pl. 2, figs. 1–5.
Didymograptus similis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 347, pl. 55, figs. 37–40.

Remarks.—The Texas specimens agree fully with the description of this species by Ruedemann.

Horizon.—*D. similis* was collected from zones 5, 6, and 7 of the upper part of the Marathon limestone (in collections 26, 47, 64, 67, and 70). Ruedemann states that this species is common in the zone of *D. bifidus* (graptolite beds 3 and 5) of the Deepkill shale in New York. Raymond (1914) lists it in zone C-1 of the Levis shale in Quebec and Miser and Purdue (1929) list it from the Mazarn shale in the Ouachita Mountains. Harris and Thomas (1938b) figure *D. similis* as one of the characteristic species of the Bendigo series in Victoria, Australia.

DIDYMOGRAPTUS SUBTENUIS (Hall)

Graptolitus tenuis (Portlock?) Hall, 1847, Paleontology of New York, vol. 1, p. 272, pl. 74, figs. 2a-d.
Didymograptus subtenuis Ruedemann, 1908, New York State Mus. Mem. 11, pp. 253–255, text figs. 160, 161, pl. 14, figs. 1, 2.
Didymograptus subtenuis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 348–349, pl. 55, figs. 6, 7, pl. 56, figs. 5, 6.

Remarks.—The Texas specimens agree well with Ruedemann's specific description.

Horizon.—A few specimens of this species were collected from the lower part of the Woods Hollow shale, zone 11 (collection 137). The type specimens came from the Normanskill shale at Kenwood, New York. Other localities in the Normanskill shale have also yielded specimens of this species. Ruedemann records it in the Glenogle shale in British Columbia, and Decker (1952) found it in the "Athens shale" at localities in Tennessee.

DIDYMOGRAPTUS V-DEFLEXUS Harris

Pl. 11, fig. 9

Didymograptus v-deflexus Harris, 1924, Royal Soc. Victoria, Proc. (n.s.), vol. 36, pp. 93–94, pl. 7, figs. 1, 2.

Remarks.—The Texas specimens agree fully with the specific description by Harris.

Horizon.—Specimens of this species were collected from only one locality (collection 141), which is the lower part of the Fort Peña formation, zone 8. Harris and Thomas (1938b) figure it as one of the characteristic species of the Yapeen series of Victoria, Australia, where it occurs with the same associates (*Cardiograptus* and *Oncograptus*) as it does in the Marathon region.

Genus CARDIOGRAPTUS Harris and Keble, 1916

CARDIOGRAPTUS CRAWFORDI Harris

Pl. 11, fig. 12

Cardiograptus crawfordi Harris, 1926, Royal Soc. Victoria, Proc. (n.s.), vol. 38, p. 57, pl. 1, figs. 5–7.
Cardiograptus crawfordi Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, p. 306, fig. 2, no. 26.

Remarks.—The Texas specimens are small, being 5 to 6 mm in length and 3.5 to 4 mm in width, but they agree in every respect with the description by Harris. Harris states that the usual dimensions are 7 mm in length and 5 mm in breadth but that "many specimens are smaller."

Horizon.—*C. crawfordi* is a common element of the fauna of zone 8. It is found in the lower part of the Fort Peña formation at several localities (collections 42, 61A, 62, and 140). Harris (1935) lists the species from the zones of *Diplograptus decoratus* and *Glyptograptus intersitus* of the Victorian Middle Ordovician. *C. crawfordi* occurs with *C. morsus*, *Oncograptus*, and *Isograptus caduceus* var. *maxima* in the Marathon sequence, but it occurs with *Trigonograptus ensiformis*, *Hallograptus etheridgei*, and *Cryptograptus schaferi* in the Victorian succession. The species appears earlier in the Marathon sequence than it does in the Australian.

CARDIOGRAPTUS MORSUS Harris and Keble

Pl. 11, figs. 13, 14

Cardiograptus morsus Harris and Keble, 1916, *in* Harris, 1916, Royal Soc. Victoria, Proc., vol. 29, pl. 1, figs. 1–4.
Cardiograptus morsus Harris, 1924, Royal Soc. Victoria, Proc. (n.s.), vol. 36, pp. 95–96.

Remarks.—The Texas specimens agree closely with the specific description by Harris (1924).

Horizon.—*C. morsus* is a characteristic element of the fauna of zone 8 in the Marathon sequence. The species was found in the lower part of the Fort Peña formation (collections 42, 107, 140, and 141) where it occurs with *Oncograptus upsilon* and several varieties of *Isograptus caduceus.* Harris and Thomas (1938b) state that *C. morsus* is the characteristic species of the upper zone of the Yapeen series in Victoria, Australia.

Genus ISOGRAPTUS Moberg, 1892

ISOGRAPTUS CADUCEUS var. DIVERGENS Harris

Pl. 11, fig. 6

Isograptus caduceus var. *divergens* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 91, text figs. 14–18.

Remarks.—The Texas specimens are like Harris' figures except that in most of the specimens, the stipes are inclined at a slightly larger angle than those figured by Harris. Some specimens show a distinct web structure at the axil much like Harris' text figure 17.

Horizon.—Specimens of this variety were collected from both the lower part of the Fort Peña formation, zone 8 (collections 110 and 141), and the upper part of the formation, zone 9 (collection 15). Harris (1933) records the variety from beds now included in the upper zone of the Yapeen series in Victoria, Australia, where its associates include forms (*Cardiograptus* and *Trigonograptus*) found in zone 8 in the Marathon sequence. Further, Harris (1935) lists the variety *divergens* from the lowest zone (zone of *Glyptograptus austrodentatus*) of the Middle Ordovician in Victoria; its associates include several forms (*G. austrodentatus, Isograptus forcipiformis,* and *Tetragraptus serra*) found in zone 9 of the Marathon sequence.

ISOGRAPTUS CADUCEUS var. IMITATA Harris

Isograptus caduceus var. *imitata* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 92, text figs. 55–59.

Remarks.—The Texas specimens are like Harris' text figures 55–58.

Horizon.—Specimens of this variety were collected from the upper part of the Fort Peña formation, zone 9 (collections 42 and 152). Harris reports the variety to be common in the highest zone of the Castlemaine series in Victoria, Australia.

ISOGRAPTUS CADUCEUS var. LUNATA Harris

Isograptus caduceus var. *lunata* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 90, text figs. 3–6.

Remarks.—The Texas specimens are like Harris' text figures 3 and 5. The stipes show only a slight variation in width (1.0 to 1.2 mm).

Horizon.—Specimens of the variety were collected from the highest beds of the Marathon limestone, zone 7 (collection 70), and from the Alsate shale (collections 18 and 113), which comprises the lower part of zone 8. In Victoria, Australia, according to Harris, the variety ranges from the upper part of the Chewton series, where it is rare, into the lowest part of the Castlemaine series, where it is the characteristic form of the lowest zone. Spjeldnaes (1953) has reported the form from the uppermost part of the lower *Didymograptus* shale, zone 3be exposed at Slemmested near Oslo, Norway.

ISOGRAPTUS CADUCEUS var. MAXIMA Harris

Pl. 11, fig. 8

Isograptus caduceus var. *maxima* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 91, text figs. 11 and 12.

Remarks.—The Texas specimens are like Harris' figures except that in some specimens, the stipes enclose a lesser angle than the figured forms.

Horizon.—Specimens of this variety were collected from the lower part of the Fort Peña formation, zone 8 (collections

61A, 88, 95, 107, 110, and 129). Harris records the variety from the middle and upper zones of the Castlemaine series in Victoria, Australia, and it is a characteristic form of the upper zone. It is associated with *I. caduceus* var. *victoriae* and *I. caduceus* var. *maximo-divergens* in the Australian sequence and is found in beds below those with *Oncograptus* and *Cardiograptus*. In the Marathon succession, the varieties *victoriae, maxima,* and *maximo-divergens* and *Oncograptus* and *Cardiograptus* are all found together.

ISOGRAPTUS CADUCEUS var. MAXIMO-DIVERGENS Harris

Pl. 11, fig. 11

Isograptus caduceus var. *maximo-divergens* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 91, fig. 13.
Isograptus walcottorum Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 354, pl. 57, figs. 26–36.

Remarks.—The Texas specimens agree well with Harris' figure 13. The stipes of the Texas specimens measure 5 mm in width and enclose an angle of 45 to 55 degrees between them. Ruedemann's figures of *I. walcottorum* also agree with Harris' figures of this variety of *I. caduceus*.

Horizon.—Specimens of this variety were obtained from the lower part of the Fort Peña formation, zone 8 (collections 88 and 141), where they are associated with *Oncograptus upsilon* and *I. caduceus* var. *victoriae*. Ruedemann's specimens came from the Glenogle shale in British Columbia. Harris records this variety from the highest zone of the Castlemaine series, only, in Victoria, Australia, where it occurs in beds below those with *O. upsilon* and above those with *I. caduceus* var. *victoriae*.

ISOGRAPTUS CADUCEUS var. VICTORIAE Harris

Pl. 11, fig. 7

Isograptus caduceus var. *victoriae* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 90, text figs. 7–10.

Remarks.—The Texas specimens agree with Harris' figures.

Horizon.—This variety is a common form in the lower part of the Fort Peña formation, zone 8 (collections 10, 95, 98A, 110, 140, and 141). Harris states that the form is the diagnostic element of the middle zone of the Castlemaine series in Victoria, Australia. In the Marathon region, the variety is associated with *Cardiograptus, Oncograptus,* and the more robust varieties of *I. caduceus,* while in Australia, it occurs in beds older than those containing *Cardiograptus* and *Oncograptus.*

ISOGRAPTUS FORCIPIFORMIS var. LATUS Ruedemann

Pl. 12, fig. 1

Isograptus forcipiformis var. *latus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 353, pl. 57, figs. 41, 42.

Remarks.—Ruedemann established this variety for forms in which the width of the stipes remains constant for the greater part of their length. Otherwise, the variety agrees with the typical form in all characters. The Texas specimens agree well with Ruedemann's description of this variety except that the stipes are slightly narrower than the described material. The stipes of the Texas specimens are 2.5 to 2.8 mm in width while Ruedemann gives a stipe width of 3.0 mm.

Horizon.—Specimens of this variety were collected from the upper part of the Fort Peña formation, zone 9 (collections 15, 16, and 28). Ruedemann's type material came from the Blakely sandstone in Arkansas. Harris (1935) lists *I. forcipiformis* from the lower three zones of the Middle Ordovician of the Victoria, Australia, sequence.

ISOGRAPTUS MANUBRIATUS (T. S. Hall)

Pl. 11, fig. 5; Pl. 12, fig. 4

Didymograptus caduceus var. *manubriatus* T. S. Hall, 1914, Royal Soc. Victoria, Proc. (n.s.), vol. 27, pp. 108–109, pl. 17, fig. 12 (not fig. 13).
Isograptus manubriatus Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, pp. 102–104, pl. 6, figs. 1a-i.

Remarks.—Harris (1933) fully discusses the character of *I. manubriatus,* and the Texas specimens agree closely with his description.

Horizon.—*I. manubriatus* was found in the lower and middle parts of the Fort Peña formation, zones 8 and 9 (collections 61A, 110, and 111). Harris records it from the Yapeen series of Victoria, Australia. It is associated with *Oncograptus upsilon* and *Isograptus caduceus* var. *divergens* in both the Marathon and Australian assemblages.

ISOGRAPTUS OVATUS (T. S. Hall)

Didymograptus ovatus T. S. Hall, 1902, Rec. Geol. Surv. Victoria, p. 33, fig. 1.
Isograptus ovatus Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, pp. 105–106, text figs. 45, 46.

Remarks.—The Texas specimens agree well with the specific description by Harris.

Horizon.—A few specimens of *I. ovatus* were collected from the upper part of the Fort Peña formation, zone 9 (collection 13). Harris records the species from the youngest zone of the Middle Ordovician in Victoria, Australia.

Genus ONCOGRAPTUS T. S. Hall, 1914

ONCOGRAPTUS UPSILON T. S. Hall

Pl. 11, figs. 10, 15

Oncograptus upsilon T. S. Hall, 1914, Royal Soc. Victoria, Proc. (n.s.), vol. 27, p. 109, pl. 17, fig. 14.
Oncograptus upsilon Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 355–356, pl. 58, fig. 5.

Remarks.—The Texas specimens agree closely with T. S. Hall's specific description.

Horizon.—Ruedemann (*in* Sellards, 1933) first reported *O. upsilon* from the Marathon region, and the writer found it to be fairly common in the lower part of the Fort Peña formation, zone 8 (collections 61B, 107, 110, 140, and 141). Harris and Thomas (1938b) figure the species as a common form in the Yapeen series in Victoria, Australia, and state that it is the characteristic element of the lower zone of that series.

ONCOGRAPTUS UPSILON var. BIANGULATUS (Harris and Keble)

Oncograptus biangulatus Harris and Keble, 1916, *in* Harris, 1916, Royal Soc. Victoria, Proc., vol. 29, pl. 1, figs. 7–9.
Oncograptus biangulatus Harris, 1924, Royal Soc. Victoria, Proc. (n.s.), vol. 36, p. 96.
Oncograptus upsilon var. *biangulatus* Harris, 1933, Royal Soc. Victoria, Proc. (n.s.), vol. 46, p. 96, text figs. 23, 24.

Remarks.—The Texas specimens agree with Harris' (1933) text figure 23 and with his discussion of the variety.

Horizon.—Specimens of this variety were collected from the lower part of the Fort Peña formation, zone 8 (collections 140 and 141). Harris records the variety from both zones in the Yapeen series in Victoria, Australia. The species has the same associates (*Cardiograptus, O. upsilon,* and *Didymograptus v-deflexus*) in both the Victorian and Marathon sequences.

Family CORYNOIDIDAE Bulman, 1944

Genus CORYNOIDES Nicholson, 1867

CORYNOIDES CALICULARIS Nicholson

Pl. 15, fig. 5

Corynoides calicularis Nicholson, 1867, Geol. Mag., vol. 4, p. 108, pl. 7, figs. 9–11.
Corynoides gracilis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 361, pl. 58, figs. 34–37a.
Corynoides gracilis mut. *perungulatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 361, pl. 58, figs. 38–46.
Corynoides calicularis Strachan, 1949, Geol. Mag., vol. 86, pp. 156–157, text fig. 1.
Not. *Corynoides calicularis* Ruedemann, 1908, New York State Mus. Mem. 11, p. 234, text figs. 126–131, pl. 13, figs. 1, 6–8.

Remarks.—In his revision of the genus *Corynoides,* Strachan (1949) has brought up to date the synonymy of this species and a part of it is given above. The Texas specimens agree with Ruedemann's description of *C. gracilis* mut. *perungulatus.* Strachan states that the American forms *C. gracilis* and *C. gracilis* mut. *perungulatus* agree well with what is accepted as *C. calicularis* in Britain, and the writer, following this opinion, includes the Texas forms in the species *C. calicularis.*

Horizon.—*C. calicularis* is a relatively common form in zones 11 (collections 104, 122, 125, and 139) and 12 (collections 94A and 136) in the Woods Hollow shale. Ruedemann records *C. gracilis* mut. *perungulatus* as abundant in the Normanskill shale in New York, the Womble shale in Arkansas, and the Stringtown shale in

Oklahoma. He also reports *C. gracilis* from the Normanskill and Snake Hill shales in New York and the Stringtown shale in Oklahoma. Strachan states that *C. calicularis* is common in the zone of *Climacograptus wilsoni* and also found in the succeeding zone—that of *Dicranograptus clingani* in the British Isles. The American occurrences of *C. calicularis* are slightly earlier than those in the British Isles.

CORYNOIDES INCURVUS Hadding

Corynoides incurvus Hadding, 1915, Lunds. Univ. Arsskr., N.F., Afd. 2, Bd. 11, p. 25, pl. 3, figs. 24–27.
Corynoides calicularis Ruedemann, 1908, New York State Mus. Mem. 11, p. 234, text figs. 126–131, pl. 13, figs. 1, 6–8.
Corynoides curtus mut. *pristinus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 360, pl. 58, figs. 30–33.
Corynoides incurvus Strachan, 1949, Geol. Mag., vol. 86, pp. 158–159, text fig. 3.

Remarks.—The Texas specimens were compared to material identified as *C. curtus* mut. *pristinus* by Ruedemann and were considered to be identical to it. Further, the measurements of specimens of this species agree with the description given by Strachan for the species *C. incurvus*. Following Strachan's suggestion, the writer includes the Texas specimens and Ruedemann's form *C. curtus* mut. *pristinus* in the species *C. incurvus*.

Horizon.—Only a few specimens of this species were found in Texas. They were collected from the Woods Hollow shale, zones 11 (collection 104) and 12 (collection 105). Ruedemann records *C. curtus* mut. *pristinus* from the Normanskill shale in New York and from low in the Viola limestone in Oklahoma. Strachan reports *C. incurvus* from the Hartfell shales in the zone of *Dicranograptus clingani*. The American representatives of this species appear slightly earlier than do the English forms.

CORYNOIDES TRICORNIS Ruedemann

Corynoides tricornis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 362, pl. 58, figs. 61–64.

Remarks.—The Texas specimens agree well with Ruedemann's specific description. The characteristic element of this species is the needlelike apertural spine with which each theca is provided. The rhabdosome is easily recognized by its short (4 mm), narrow (0.3 to 0.5 mm) size and the apertural spines.

Horizon.—Specimens of *C. tricornis* were collected from the lower and middle parts of the Woods Hollow shale, zones 11 (collection 137) and 12 (collection 103). Ruedemann's type material came from the lower part of the "Athens" shale near Bristol, Tennessee. He also reports it in the Glenogle shale in British Columbia.

Family CRYPTOGRAPTIDAE Hadding, 1915

Genus CRYPTOGRAPTUS Lapworth, 1880

CRYPTOGRAPTUS SCHAFERI (Lapworth)

Pl. 12, figs. 7, 8

Cryptograptus tricornis var. *schaferi* Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, pl. 5, figs. 28a, b.
Cryptograptus tricornis var. *schaferi* Elles and Wood, 1908, Mon. British Grapt., p. 299, text figs. 201a, b, pl. 32, figs. 13a-c.
Cryptograptus schaferi Bulman, 1933, Quart. Jour. Geol. Soc. London, vol. 89, pp. 352–353.
Cryptograptus schaferi Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, p. 304, fig. 3, nos. 11, 12.

Remarks.—Bulman raised Lapworth's variety *schaferi* of *C. tricornis* to specific rank, and the writer follows this opinion. *C. schaferi* is 2.0 mm in width, whereas *C. tricornis* is 1.5 mm in width, and the short free edges of the thecae in *C. schaferi* give rise to distinct mucronate extensions. Further, there are no conspicuous basal spines in *C. schaferi* whereas in *C. tricornis* such spines are prominent. The rhabdosomes of the Texas specimens are 15 to 20 mm in length, parallel sided, and have a breadth of about 2.0 mm. The thecae number 11 to 12 in 10 mm and have conspicuous mucronate extensions. The initial two thecae appear to have grown downward before upward growth commenced.

Horizon.—The species is common in the upper part of the Fort Peña formation, zone 9 (collections 13, 14, 15, 28, and 98). Elles and Wood record the species from a

younger horizon, the zone of *Nemagraptus gracilis*, in the Glenkiln shales in the British Isles. Harris and Thomas (1938) state that it is common in the middle two zones (zones of *Glyptograptus intersitus* and *Diplograptus decoratus*) of the Middle Ordovician of Victoria, Australia. The Texas specimens occur with similar assemblages to those with which the species occurs in Australia. Probably all of the Middle Ordovician forms referred to *C. tricornis* by the several Australian authors should be referred to *C. schaferi*; therefore, *C. tricornis* would not have as long a range in Australia as would appear from the literature.

CRYPTOGRAPTUS TRICORNIS (Carruthers)

Pl. 15, fig. 9

Diplograpsus tricornis Carruthers, 1858, Royal Phys. Soc. Edinburgh, Trans., vol. 1, p. 468, fig. 2.

Cryptograptus tricornis Elles and Wood, 1908, Mon. British Grapt., pp. 296–298, text figs. 200a-j, pl. 32, figs. 12a-d.

Cryptograptus tricornis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 446, pl. 76, figs. 23–33.

Cryptograptus tricornis mut. *insectiformis* Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 446–447, pl. 76, figs. 34–41.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood. Bulman (personal communication, September 1956) states that he considers *C. tricornis* mut. *insectiformis* to be merely an immature scalariform view of *C. tricornis*, and the writer concurs with this opinion.

Horizon.—*C. tricornis* is common in the Woods Hollow shale where it was collected from both zones 11 (collections 49, 104, 122, 125, 137, 139, and 150) and 12 (collections 94A, 94B, 100, 103, 105, and 136). Ruedemann reports *C. tricornis* as common in the Normanskill shale in New York, and that it is known from the Magog shale in Quebec, the Womble shale in Arkansas, the Stringtown shale and Viola limestone in Oklahoma, and the Glenogle shale in British Columbia. Further, he records *C. tricornis* mut. *insectiformis* from the Snake Hill shale in New York and from the Viola limestone. In the British Isles, *C. tricornis* is a long-ranging species. Elles and Wood state that it is abundant in the zones of *Didymograptus murchisoni, Nemagraptus gracilis, Climacograptus peltifer*, and *Climacograptus wilsoni*, and that it is also found in the zones of *Didymograptus extensus, Didymograptus bifidus*, and *Dicranograptus clingani*. Thomas and Keble (1933) record *C. tricornis* from the Gisbornian and Eastonian series of the Upper Ordovician in Victoria, Australia.

Genus GLOSSOGRAPTUS Emmons, 1855

GLOSSOGRAPTUS ACANTHUS Elles and Wood

Glossograptus acanthus Elles and Wood, 1908, Mon. British Grapt., p. 314, text figs. 208a, b, pl. 33, figs. 4a-c.

Glossograptus acanthus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 302–303, fig. 3, nos. 13–16.

Remarks.—The Texas specimens agree well with Elles and Wood's specific description except that no septal spines were observed. However, Elles and Wood were not certain that septal spines were present. The preservation of the Texas specimens is such that it is difficult to see both of the apertural spines belonging to each theca (Elles and Wood also mention that more than one of the two apertural spines is rarely seen), but the two spines appear to be preserved one almost on top of the other, so that the process which extends out from the aperture of each theca appears thicker than it really is. *G. acanthus* is readily recognized by its subfusiform outline, its breadth (up to 4 mm), and its robust spines.

Horizon.—Specimens of *G. acanthus* were collected from the upper part of the Fort Peña formation, in zone 9 (collections 13, 14, and 149), where it occurs with *Hallograptus etheridgei, Trigonograptus ensiformis*, and *Glossograptus hincksii*. Elles and Wood report that *G. acanthus* occurs in the zones of *Didymograptus bifidus* and *D. extensus* of the Arenig, Skiddaw slates in England. Harris and Thomas (1935) state that *G. acanthus* is common in the Middle Ordovician (zone of *Glypto-*

graptus intersitus) of Victoria, Australia. It occurs there in an assemblage quite like that with which it occurs in Texas. It occurs in an older horizon in England than it does in Texas and Australia.

GLOSSOGRAPTUS ARMATUS Nicholson

Glossograptus armatus Nicholson, 1869, Ann. Mag. Nat. Hist., vol. 4, p. 234, pl. 11, fig. 8.
Glossograptus armatus Elles and Wood, 1908, Mon. British Grapt., pp. 312–313, text fig. 207, pl. 33, figs. 5a-e.

Remarks.—The Texas specimens agree fully with the specific description by Elles and Wood.

Horizon.—A few specimens of *G. armatus* were collected from one locality (collection 137) which is in the lower part of the Woods Hollow shale, zone 11. Elles and Wood report that the species is a rare fossil in the upper part of the Skiddaw slates and in the Glenkiln shale in the British Isles.

GLOSSOGRAPTUS CILIATUS Emmons?

Remarks.—All the Texas specimens are small and are probably young forms. They are like Ruedemann's (1947) figures of the early stages of *G. ciliatus* (pl. 77, figs. 28–31) and have, therefore, been referred to that species. No adult specimens were found.

Horizon.—The specimens referred to *G. ciliatus* were collected from both zones 11 (collections 104 and 139) and 12 (collections 94A, 127, and 136) in the Woods Hollow shale. Ruedemann records *G. ciliatus* from the Normanskill shale in New York, the Womble shale in Arkansas, and the Viola limestone in Oklahoma.

GLOSSOGRAPTUS HINCKSII (Hopkinson)

Pl. 12, fig. 9a

Diplograptus hincksii Hopkinson, 1872, Geol. Mag., vol. 9, p. 507, pl. 12, fig. 9.
Glossograptus hincksii Elles and Wood, 1908, Mon. British Grapt., pp. 309–312, text figs. 205 a-f, pl. 33, figs. 2 a-j.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood.

Horizon.—*G. hincksii* is a characteristic species of zone 9 (collections 13, 28, and 149), which encompasses the upper part of the Fort Peña formation. It was also collected from the lower part of the Woods Hollow shale (collection 137) which is in zone 11. Elles and Wood report the species to be present in the zones of *Nemagraptus gracilis, Mesograptus multidens,* and *Climacograptus wilsoni* in the British succession. Harris (1935) lists *G. hincksii* as a common fossil in the upper two zones of the Middle Ordovician and Thomas and Keble (1933) list it from the Gisbornian series of the Upper Ordovician in Victoria, Australia. The species occurs earlier and does not range as high in the Marathon and Victorian successions as it does in the British.

GLOSSOGRAPTUS HORRIDUS Ruedemann

Glossograptus ciliatus mut. *horridus* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 383–384, pl. 26, figs. 8, 9, pl. 27, fig. 5.
Glossograptus horridus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 451–452, pl. 77, figs. 17–22.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description.

Horizon.—Specimens of *G. horridus* were collected from one locality (collection 28) which is in the upper part of the Fort Peña formation, zone 9. Ruedemann reports the species in shales from Summit, Nevada, and from the Glenogle shale in British Columbia.

GLOSSOGRAPTUS HYSTRIX Ruedemann

Glossograptus hystrix Ruedemann, 1904, New York State Mus. Mem. 7, pp. 724–725, text fig. 101, pl. 16, figs. 27–29.
Glossograptus hystrix Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 452, pl. 77, figs. 1–4, not figs. 5–8.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description and with the figures of the New York specimens. The figured forms from Arkansas are narrower and possess a distinct virgula. They appear to be a species distinct from *G. hystrix.*

Horizon.—Specimens of *G. hystrix* were collected from the upper part of the Fort Peña formation, zone 9 (collections 15

and 98). Ruedemann records the species from graptolite bed 7 (zone of *Diplograptus dentatus*) of the Deepkill shale in New York, and from the Ash Hill quarry at Mt. Merino, New York.

Family LEPTOGRAPTIDAE Lapworth, 1879

Genus LEPTOGRAPTUS Lapworth, 1873

LEPTOGRAPTUS ANNECTANS (Walcott)

Graptolithus annectans Walcott, 1881, Albany Inst. Trans., vol. 10 (Adv. sheet 1879), pp. 20, 35, pl. 1, fig. 2, 2a.
Leptograptus annectans, Lapworth, 1887, Royal Soc. Canada, Proc. Trans., vol. 4, p. 183.
Leptograptus annectans Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 362–363, pl. 59, figs. 1–6.

Remarks.—The Texas specimens are poorly preserved, but the measurements agree with the description of *L. annectans* by Ruedemann. The stipes are long (4 cm) and thin (0.4 mm increasing to 0.8 mm) and show a gentle double curvature. They diverge at a 290-degree angle. The thecae number 10 in 10 mm, overlap half their length, and are inclined at 15 degrees.

Horizon.—Specimens of *L. annectans* were collected from one locality (collection 83A) in the middle part of the Maravillas chert, which is within zone 14. Walcott's type came from the Utica shale at Holland Patent, New York. Ruedemann records the species from the Fulton shale at Cincinnati and from the Viola limestone in the Arbuckle Mountains, Oklahoma.

LEPTOGRAPTUS FLACCIDUS mut. TRENTONENSIS Ruedemann

Pl. 15, fig. 7

Leptograptus flaccidus mut. *trentonensis* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 261–262, text. figs. 172–175, pl. 14, figs. 6, 7.
Leptograptus flaccidus mut. *trentonensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 366–367, pl. 59, figs. 14–17.

Remarks.—The Texas specimens agree closely with Ruedemann's description, except that the angle of divergence of the stipes is 240 to 260 degrees in the Texas specimens while in the types it is 220 to 240 degrees. In one of the Texas specimens the sicula measures 2.0 mm in length. The usual length is 1.5 mm, according to Ruedemann's description.

Horizon.—This species was collected from zone 11, the lower part of the Woods Hollow shale (collections 49, 125, and 139). Ruedemann's types came from the Normanskill shale in New York, and he has recorded it from the base of the Viola limestone in Oklahoma.

LEPTOGRAPTUS VALIDUS var. INCISUS Lapworth?

Remarks.—The Texas specimens tentatively referred to this variety are poorly preserved and details are difficult to see. They have long slender stipes which are about 0.4 mm in width. The thecae number 8 to 10 in 10 mm, overlap about one-third of their extent, and are inclined at an angle of 15 degrees to the stipe. In these characters, the Texas specimens agree with the description of *L. validus* var. *incisus*, but the preservation of the sicular region and the detail of the thecae is too poor to warrant definite identification.

Horizon.—These forms were collected from zones 11 (collections 104 and 139) and 12 (collection 94A) in the Woods Hollow shale. *L. validus* var. *incisus* is recorded from the Glenkiln shales of southern Scotland by Elles and Wood (1903, p. 115).

Genus NEMAGRAPTUS Emmons, 1855

NEMAGRAPTUS EXILIS var. LINEARIS Ruedemann

Nemagraptus exilis var. *linearis* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 290–291, text figs. 204, 205, pl. 17, figs. 10–12.
Nemagraptus exilis var. *linearis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 372, pl. 61, figs. 10–14.

Remarks.—The Texas specimens of this variety are poorly preserved but agree with Ruedemann's description. The exceeding slenderness and the restriction of the secondary stipes to a small number at the distal ends of the main stipes distinguish this variety from the true *N. exilis*.

Horizon.—This variety was found in the lower part of the Woods Hollow shale, zones 11 and 12 (collections 104, 136, 137, 139, and 148). Ruedemann reports the variety to be present in the Normanskill

shale in New York, the Glenogle shale in British Columbia, and the "Athens" shale near Bristol, Tennessee.

NEMAGRAPTUS GRACILIS (Hall)

Pl. 15, fig. 13

Graptolithus gracilis Hall, 1847, Paleontology of New York, vol. 1, p. 274, pl. 74, figs. 6a-d.
Nemagraptus gracilis Elles and Wood, 1903, Mon. British Grapt., pp. 127–129, text figs. 76a-c, pl. 19, figs. 1a-f.
Nemagraptus gracilis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 367–368, pl. 60, figs. 1–12.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood and by Ruedemann.

Horizon.—*N. gracilis* was found in zone 11 (collections 122 and 139), in the lower part of the Woods Hollow shale. The species is the most typical, but not the most common, form of this zone. Hall described the species from the Normanskill shale in New York, and it has since been reported from Newfoundland, Maine, New Jersey, Virginia, Alabama, and Arkansas (Ruedemann, 1947). Elles and Wood record it as one of the commonest elements of the graptolite fauna of the Glenkiln shales, and Harris and Thomas (1938b) list it as one of the characteristic species of the lower part of the Gisbornian series in the Upper Ordovician of Victoria, Australia.

NEMAGRAPTUS GRACILIS var. SURCULARIS (Hall)

Graptolithus gracilis Hall, 1860, (pars) New York State Cab. Nat. Hist., 13th Ann. Rept., p. 56, figs. 1–4.
Coenograptus surcularis Hall, 1868, New York State Cab. Nat. Hist., 20th Ann. Rept., p. 179, figs. 13–16.
Nemagraptus gracilis var. *surcularis* Elles and Wood, 1903, Mon. British Grapt., pp. 129–130, text figs. 77a-c, pl. 19, figs. 2a-d.
Nemagraptus gracilis var. *surcularis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 370, pl. 60, figs. 17–24.

Remarks.—The Texas specimens agree well with Elles and Wood's description.

Horizon.—This variety of *N. gracilis* was found associated with the typical form in zone 11 (collection 137), the lower part of the Woods Hollow shale. Ruedemann records the variety from the Normanskill shale of New York and the Stringtown shale of Oklahoma. Elles and Wood state that the variety is a "comparatively common form in the Glenkiln shales of South Scotland."

Family DICRANOGRAPTIDAE Lapworth, 1873

Genus DICELLOGRAPTUS Hopkinson, 1871

DICELLOGRAPTUS COMPLANATUS Lapworth

Pl. 20, fig. 1

Dicellograptus complanatus Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, p. 160, pl. 5, figs. 17a-e.
Dicellograptus complanatus Elles and Wood, 1904, Mon. British Grapt., pp. 139–140, text figs. 84a-e, pl. 20, figs. 1a-d.
Dicellograptus complanatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 376–377, pl. 62, figs. 4–10.

Remarks.—The Texas specimens agree with the description by Elles and Wood in the character of the thecae, in number of thecae (8 to 10 in 10 mm), in the width of the stipes, and in the angle of divergence of the stipes (240 to 270 degrees). The stipes are shorter than those described by Elles and Wood.

Horizon.—*D. complanatus* was obtained from collections made 8 inches and 1 inch from the top of the Maravillas chert, zone 15 (collections 60 and 147). The species was originally described from the upper part of the Hartfell shales of southern Scotland. Ruedemann (1947) records it from the Sylvan shale in the Arbuckle Mountains, Oklahoma, and from the Polk Creek shale in the Ouachita Mountains in Arkansas. Harris and Thomas (1938b) report a *Dicellograptus* cf. *complanatus* from the highest beds of the Bolindian series of the Upper Ordovician in Victoria, Australia.

DICELLOGRAPTUS COMPLANATUS var. ARKANSASENSIS Ruedemann

Pl. 20, fig. 2

Dicellograptus complanatus var. *arkansasensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 377, pl. 62, figs. 11–15.

Remarks.—The Texas specimens agree closely with Ruedemann's description. This variety is similar to the variety *ornatus* but lacks the stout lateral spines so characteristic of that form.

Horizon.—This variety of *D. complanatus* was found associated with the typical

form and the variety *ornatus* in the top of the Maravillas chert, zone 15 (collections 60 and 147). Ruedemann (1947) described the variety from the Polk Creek shale in Arkansas.

DICELLOGRAPTUS COMPLANATUS var. ORNATUS Elles and Wood

Pl. 20, fig. 3

Dicellograptus complanatus var. *ornatus* Elles and Wood, 1904, Mon. British Grapt., pp. 140–141, text figs. 85a, b, pl. 20, figs. 2a-c.
Dicellograptus complanatus var. *ornatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 377–378, pl. 62, figs. 16–20.

Remarks.—The Texas specimens not only possess the characteristic stout lateral spines of the variety but also agree closely with the description given by Elles and Wood in all other characters.

Horizon.—This variety of *D. complanatus* was found in association with *D. complanatus* and *D. complanatus* var. *arkansasensis* in the uppermost foot of the Maravillas chert, zone 15 (collection 60). The variety was originally described from the upper part of the Hartfell shales (the zone of *Dicellograptus anceps*) in southern Scotland. It has been recorded by T. S. Hall (1920) from New South Wales and by Thomas and Keble (1933) from the Bolindian series of the Upper Ordovician of Victoria, Australia. Ruedemann (1947) reported the species from the Ordovician shale of Trail Creek, Blaine County, Idaho.

DICELLOGRAPTUS DIVARICATUS (Hall)

Pl. 15, fig. 12

Graptolithus divaricatus Hall, 1859, Paleontology of New York, vol. 3, pp. 513–514, figs. 1–4.
Dicellograptus divaricatus Elles and Wood, 1904, Mon. British Grapt., pp. 143–144, text figs. 87a-c, pl. 20, figs. 5 a, b.
Dicellograptus divaricatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 378–379, pl. 62, figs. 22–25.

Remarks.—The Texas specimens agree well with the specific description by Ruedemann.

Horizon.— *D. divaricatus* was found in the Woods Hollow shale, zones 11 and 12 (collections 104, 122, 127, 136, and 139). The species was originally described from the Normanskill shale in New York, and it has been reported in the Womble and Stringtown shales in Arkansas and Oklahoma by Ruedemann. In the British Isles, the species is recorded from the Glenkiln shale by Elles and Wood. Harris and Thomas (1938b) state that the species is characteristic of the Gisbornian series of the Upper Ordovician of Victoria, Australia.

DICELLOGRAPTUS DIVARICATUS var. SALOPIENSIS Elles and Wood

Pl. 16, fig. 1

Dicellograptus divaricatus var. *salopiensis* Elles and Wood, 1904, Mon. British Grapt., pp. 145–146, text figs. 89a, b, pl. 20, figs. 7a-e.
Dicellograptus divaricatus var. *salopiensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 380, pl. 63, figs. 2–3.

Remarks.—The Texas specimens are poorly preserved, but the stipes maintain a uniform width of 15 mm throughout their length and the thecae are of the same type as *D. divaricatus*. Elles and Wood give these characteristics as diagnostic of this variety.

Horizon.—The variety was found in zone 12 (collections 127 and 136) in the upper part of the Woods Hollow shale. Ruedemann reports it in the Normanskill shale of New York and the Stringtown shale of Oklahoma, and Elles and Wood report it in the Glenkiln shale of southern Scotland. Thomas and Keble (1933) list it from the Gisbornian series of the Australian Upper Ordovician.

DICELLOGRAPTUS FORCHAMMERI (Geinitz)?

Remarks.—Some poorly preserved specimens of a *Dicellograptus* are questionably referred to this species. The stipes are about 1 to 1.2 mm in breadth, and the thecae are the same number (8 to 10 in 10 mm) and have the same characteristics as given in the description of *D. forchammeri* by Elles and Wood (1904, Mon. British Grapt., pp. 150–152, text figs. 94a-d, pl. 22, figs. 1a-d). However, no detail of the proximal end can be seen and specific identification is not warranted.

Horizon.—The specimens tentatively re-

ferred to *D. forchammeri* were found in the middle part of the Maravillas chert, zone 14 (collections 83B and 93). According to Elles and Wood (1904), *D. forchammeri* is common in the British Isles in the zone of *Dicranograptus clingani* of the Hartfell shales, but it ranges from the zone of *Nemagraptus gracilis* in the Glenkiln shales to the zone of *Pleurograptus linearis* in the upper part of the Hartfell shales. The species is listed from the Viola limestone in Oklahoma (Ruedemann) and from the lower part of the Bolindian series in the Australian Upper Ordovician by Thomas and Keble (1933).

DICELLOGRAPTUS FORCHAMMERI var. FLEXUOSUS Lapworth

Pl. 19, fig. 1

Dicellograptus forchammeri var. *flexuosus* Lapworth, 1876, Cat. West. Scottish Foss., pl. 4, fig. 90.
Dicellograptus forchammeri var. *flexuosus* Elles and Wood, 1904, Mon. British Grapt., pp. 152–153, text figs. 95a-d, pl. 22, figs. 2a-d.
Dicellograptus forchammeri Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 382, pl. 63, figs. 13–20.

Remarks.—The Texas specimens agree in the character and number of thecae (10 to 8 in 10 mm) with the description of this variety given by Elles and Wood, but the width of the stipes is slightly less (0.4 mm at their origin and 0.8 mm distally). The Texas forms are immature, however, and the longest stipes measure but 5 cm in length while stipe lengths up to 14 cm were recorded by Elles and Wood.

Horizon.—The specimens of *D. forchammeri* var. *flexuosus* were collected from the lower part of the Maravillas chert, zone 13 (collections 134 and 134A). The variety is found in the Hartfell shales (zones of *Climacograptus wilsoni* and *Dicranograptus clingani*) of southern Scotland. The variety occurs in the Viola limestone and the Polk Creek shale of Arkansas. Thomas (1932) included *D. forchammeri* var. *flexuosus* in a list of graptolites from Upper Ordovician localities in Australia.

DICELLOGRAPTUS GURLEYI Lapworth

Pl. 16, fig. 9

Dicellograptus gurleyi Lapworth MS, 1890.
Dicellograptus gurleyi Gurley, 1896, Jour. Geol., vol. 4, pp. 70–71.
Dicellograptus gurleyi Ruedemann, 1908, New York State Mus. Mem. 11, pp. 303–306, text figs. 223–228, pl. 19, figs. 7–10.
Dicellograptus gurleyi Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 382–383, pl. 63, figs. 21–33.

Remarks.—The Texas specimens are all immature forms, but in the character and number of thecae and in the character of the proximal end they agree with the description by Ruedemann.

Horizon.—*D. gurleyi* was found in zones 11 and 12 (collections 122, 136, 137, and 139) in the Woods Hollow shale. The type material came from the Normanskill shale at Stockport, New York, and Ruedemann found the species in collections from other localities in the Normanskill shale. Decker's (1952) collections from the Womble shale of Arkansas included this species. Teale (1919) listed *D. gurleyi* from the Upper Ordovician of Victoria, Australia.

DICELLOGRAPTUS GURLEYI var. EXILIS Ruedemann

Dicellograptus gurleyi var. *exilis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 383, pl. 63, figs. 34–36.

Remarks.—The stipes of the Texas specimens are slightly more slender (0.2 to 0.3 mm in breadth) than Ruedemann's description, but the specimens agree in all other features.

Horizon.—The variety was collected from zone 11, the lower part of the Woods Hollow shale (collection 137). Ruedemann described the variety from material collected from the "Athens shale" at Pratts Ferry, Alabama.

DICELLOGRAPTUS INTORTUS Lapworth

Pl. 15, fig. 1

Dicellograptus intortus Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, p. 161, pl. 5, fig. 19a.
Dicellograptus intortus Elles and Wood, 1904, Mon. British Grapt., pp. 146–147, text figs. 90a-d, pl. 20, figs. 4a-f.
Dicellograptus intortus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 383–384, pl. 64, figs. 1–3.

Remarks.—The Texas specimens agree well with the specific description given by Elles and Wood.

Horizon.—This species was found in zones 11 and 12 in the Woods Hollow shale (collections 104, 122, 136, 139, 148, and 150). Elles and Wood record it from the Glenkiln shales in South Scotland. Ruedemann reports it from the Normanskill shale in New York and the Womble shale in Arkansas. Harris and Thomas (1938b) figure *D. intortus* with the characteristic forms of the Gisbornian series of the Upper Ordovician of Victoria, Australia.

DICELLOGRAPTUS MOFFATENSIS var. ALABAMENSIS Ruedemann

Pl. 15, fig. 10

Dicellograptus moffatensis var. *alabamensis* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 310–312, text figs. 234–236, pl. 20, figs. 1, 2.
Dicellograptus moffatensis var. *alabamensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 385, pl. 64, figs. 12–16.

Remarks.—The Texas specimens agree with the description of this variety given by Ruedemann, except that the web between the stipes at the proximal end is very slight, whereas in the type material it is more prominent.

Horizon.—*O. moffatensis* var. *alabamensis* was collected from zone 11, the lower part of the Woods Hollow shale (collections 139 and 150). Ruedemann described the variety from the "Athens shale" at Pratts Ferry, Alabama.

DICELLOGRAPTUS PATULOSUS Lapworth

Dicellograptus patulosus Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, p. 162, pl. 5, figs. 18a-f.
Dicellograptus patulosus Elles and Wood, 1904, Mon. British Grapt., pp. 147–148, text figs. 91a-e, pl. 21, figs. 5a-e.
Dicellograptus patulosus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 385, pl. 64, figs. 17–19.

Remarks.—The Texas specimens of *D. patulosus* are immature forms but they agree with the description given by Elles and Wood of the proximal end and of the character and number of thecae.

Horizon.—*D. patulosus* was collected from one locality within zone 11 (collection 137) near the middle of the Woods Hollow shale. This species occurs in a single zone in the Glenkiln shales near their upper limit and Ruedemann reports it from the Stringtown shale in Arkansas.

DICELLOGRAPTUS PUMILUS Lapworth

Dicellograptus pumilus Lapworth, 1876, Cat. West. Scottish Foss., pl. 4, fig. 81.
Dicellograptus pumilus Elles and Wood, 1904, Mon. British Grapt., p. 149, text figs. 92a, b, pl. 21, figs. 3a-f.

Remarks.—The Texas specimens agree with the specific description given by Elles and Wood except for a few minor differences. The character and number of thecae are the same as in Elles and Wood's description, and the breadth of the stipes is the same. The stipes of the Texas specimens diverge at an angle of 300 to 305 degrees, while in the type forms, the stipes diverge at a 310-degree angle. The stipes are 1 to 2 cm long and are slightly curved. The characteristic wide axil of this species is present in all the Texas specimens.

Horizon.—*D. pumilus* was collected from the middle part of the Maravillas chert, zone 14 (collection 132). Elles and Wood record the species from the lower Hartfell shales of Caradoc age in southern Scotland. Thomas and Keble (1933) list the species from the lower part of the Bolindian series in the Upper Ordovician of Victoria, Australia.

DICELLOGRAPTUS SEXTANS (Hall)

Graptolithus sextans Hall, 1847, Paleontology of New York, vol. 1, p. 273, pl. 74, figs. 3a-e.
Dicellograptus sextans Elles and Wood, 1904, Mon. British Grapt., pp. 153–155, text figs. 96a-b, pl. 21, figs. 1a-c.
Dicellograptus sextans Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 386–387, pl. 64, figs. 28–31.

Remarks.—The Texas specimens agree with the specific description by Elles and Wood except that the stipes diverge at an angle of 310 to 315 degrees, while in the typical British material the stipes diverge at an angle of 300 degrees.

Horizon.—*D. sextans* was found in abundance in both zones 11 and 12 in the Woods Hollow shale (collections 49, 100, 103, 105, 122, 125, 127, 136, 139, 148, and 150).

Ruedemann records this species from the Normanskill shale of New York, and Elles and Wood report it in the Glenkiln shales in the British Isles. Harris and Thomas (1938b) figure it as one of the important forms in the Gisbornian series of the Upper Ordovician of Victoria, Australia. The species is a common form in the zone of *Nemagraptus gracilis* in the Marathon, Australian, and British successions.

DICELLOGRAPTUS SEXTANS var. EXILIS Elles and Wood

Pl. 15, fig. 11

Dicellograptus sextans var. *exilis* Elles and Wood, 1904, Mon. British Grapt., p. 155, text fig. 97, pl. 21, figs. 2a-d.
Dicellograptus sextans var. *exilis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 387, pl. 64, figs. 32, 33.

Remarks.—The stipes of the Texas specimens have, as is true of the English type material, about one-half the width of the true *D. sextans* but agree with the typical form in all other characters.

Horizon.—This variety occurs in the same zones as *D. sextans* itself—zones 11 and 12 in the Woods Hollow shale (collections 104, 136, and 139). Elles and Wood record the variety from the Glenkiln shale, and Ruedemann has found it in the Normanskill shale in New York.

DICELLOGRAPTUS SMITHI Ruedemann

Pl. 15, fig. 3b

Dicellograptus smithi Ruedemann, 1908, New York State Mus. Mem. 11, pp. 313–315, text figs. 237, 238, pl, 19, figs. 3–6.
Dicellograptus smithi Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 388, pl. 65, figs. 1–13.

Remarks.—The Texas specimens agree well with Ruedemann's specific description.

Horizon.—*D. smithi* was found in zones 11 (collections 122 and 139) and 12 (collection 136) in the Woods Hollow shale. Ruedemann's type material came from the "Athens" shale near Pratts Ferry, Alabama. He also reports it from the Normanskill shale near Clinton, New Jersey, and from the Womble shale in Arkansas.

Genus DICRANOGRAPTUS Hall, 1865

DICRANOGRAPTUS BREVICAULIS Elles and Wood

Pl. 15, fig. 2

Dicranograptus brevicaulis Elles and Wood, 1904, Mon. British Grapt., pp. 168–169, text fig. 105, pl. 24, figs. 3a-d.

Remarks.—The Texas specimens are very small but agree well with Elles and Wood's specific description. The biserial portion is 2 to 3 mm in length; in the largest Texas specimens, the uniserial portion is 5 mm in length and is nearly straight. In the number of thecae (10 to 11 in 10 mm), the character of the thecae, the width of the stipes, and in the angle between the stipes, the Texas specimens agree with the description of the British material.

Horizon.—Specimens of *D. brevicaulis* were collected from the lower part of the Woods Hollow shale zone 11 (collections 104 and 122). Elles and Wood report the species to be present in the Glenkiln shales of Shropshire and to be abundant in the same shales in southern Scotland. Harris and Thomas (1938b) figure the species as a common form in the Upper Ordovician, Gisbornian series of Victoria, Australia. *D. brevicaulis* occurs with *Nemagraptus gracilis* and *Dicellograptus sextans* in the British, Marathon, and Victorian sequences.

DICRANOGRAPTUS CONTORTUS Ruedemann

Dicranograptus contortus Ruedemann, 1908, New York State Mus. Mem. 11, p. 337, text figs. 275–278, pl. 23, fig. 9.
Dicranograptus contortus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 389, pl. 65, figs. 14–36.

Remarks.—The Texas specimens agree well with Ruedemann's specific description except that the width of the stipes is slightly less. The stipes of the Texas specimens are 0.7 mm wide in the biserial and 0.6 mm wide in the uniserial portion compared to 0.8 mm and 0.7 mm width for the same portions of the type specimens.

Horizon.—A few specimens of this species were collected from one locality (collection 104) which is in the lower part of the Woods Hollow shale, zone 11. Ruede-

mann's types came from the Normanskill shale at Kenwood, New York. He also records the species from the Hailey quadrangle, Idaho, and from the shale of Three Mile Hill at Bay of Exploits, Newfoundland.

DICRANOGRAPTUS NICHOLSONI Hopkinson

Pl. 17, fig. 6

Dicranograptus nicholsoni Hopkinson, 1870, Geol. Mag., vol. 7, p. 357, pl. 16, fig. 3.
Dicranograptus nicholsoni Elles and Wood, 1904, Mon. British Grapt., pp. 171–173, text figs. 108a-e, 109f, g, pl. 25, figs. 1a-b.
Dicranograptus nicholsoni Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 391–392, pl. 66, figs. 5–11.

Remarks.—The Texas specimens agree well with the description by Ruedemann. The length of the biserial portion is but 4 to 5 mm which is slightly shorter than in the British specimens and the width of the biserial portion is but 2 mm while in the British specimens it is 2.5 mm. Ruedemann notes that in many of the American representatives of this species, the length and width of the biserial portion are less than in the British specimens. In all other characters, however, the American and English specimens are the same.

Horizon.—Specimens of *D. nicholsoni* were collected from the lower part of the Maravillas chert, zone 13 (collections 134 and 134A). Ruedemann states that the typical form of this species is found in the Utica shale in New York and that it is extremely common in the middle horizon of the Utica shale. He also records the species from the Snake Hill shale and Indian Ladder beds in New York and the Fulton shale of the Eden group at Cincinnati. Elles and Wood report *D. nicholsoni* to be an abundant fossil in Great Britain near the top of the Glenkiln shales and in the lowest beds of the Hartfell shales and to be especially abundant and well preserved in the zone of *Climacograptus wilsoni.* Harris and Thomas (1938b) figure *D. nicholsoni* as a characteristic form of the Upper Ordovician, Eastonian series of Victoria, Australia.

DICRANOGRAPTUS NICHOLSONI var. GENICULATUS Ruedemann and Decker

Pl. 17, fig. 8

Dicranograptus nicholsoni var. *geniculatus* Ruedemann and Decker, 1934, Jour. Paleont., vol. 8, pp. 312–313, pl. 41, figs. 8, 8a.
Dicranograptus nicholsoni mut. *geniculatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 393, pl. 66, figs. 21–24.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description.

Horizon.—Specimens of this form were collected from the basal beds of the Maravillas chert, zone 13 (collections 73 and 134A). Ruedemann states that *D. nicholsoni* mut. *geniculatus* is especially common in the upper part of the Stringtown shale in the Oklahoma part of the Ouachita Mountains and has been found in the lower part of the Viola limestone at several localities. The writer collected this form from the upper part of the Womble shale in Arkansas.

Family DIPLOGRAPTIDAE Lapworth, 1873

Subfamily CLIMACOGRAPTINAE Frech, 1897

Genus CLIMACOGRAPTUS Hall, 1865

CLIMACOGRAPTUS ANTIQUUS Lapworth

Climacograptus antiquus Lapworth, 1873, Geol. Mag., vol. 10, p. 134 (nom. nud.).
Climacograptus coelatus Lapworth, 1873, Cat. West. Scottish Foss., p. 6, pl. 1, fig. 56.
Climacograptus antiquus Elles and Wood, 1906, Mon. British Grapt., pp. 199–200, text figs. 130a-d, pl. 27, figs. 4a-e.
Climacograptus antiquus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 422–423, pl. 71, figs. 44–48.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood.

Horizon.—Ruedemann (*in* Sellards, 1933) first reported *C. antiquus* from the Marathon region. The writer collected it from the basal beds of the Maravillas chert, zone 13 (collections 73, 106, 134, 134A, and 135). Ruedemann reports the species from the Glenogle shale in British Columbia and the Stringtown shale in Oklahoma. The writer has identified it in a collection from the upper part of the Womble shale in Arkansas. Elles and Wood record the

species from the Glenkiln shales and their equivalents in southern Scotland, North Wales, and northern Ireland. Thomas and Keble (1933) list *C. antiquus* from the Gisbornian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS ANTIQUUS var. BURSIFER Elles and Wood

Climacograptus antiquus Lapworth var. *bursifer* Elles and Wood, 1906, Mon. British Grapt., p. 201, text figs. 131a, b, pl. 27, figs. 6a-d.

Remarks.—A few specimens were collected in the Marathon succession which agree well with the description of this variety by Elles and Wood except that the Texas specimens have even more closely set thecae (14 to 15 in 10 mm) than the English forms (12 to 14 in 10 mm).

Horizon.—Specimens of this variety were collected from the upper part of the Woods Hollow shale, zone 12 (collections 94A and 94C). Elles and Wood record it from the Glenkiln shales and their equivalents in southern Scotland and Wales. Thomas and Keble (1933) list the variety from the Gisbornian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS BICORNIS (Hall)

Pl. 16, figs. 10, 11; Pl. 19, fig. 4

Graptolithus bicornis Hall, 1847, Paleontology of New York, vol. 1, p. 268, pl. 73, figs. 2a-s.
Climacograptus bicornis Elles and Wood, 1906, Mon. British Grapt., pp. 193–195, text figs. 126a-d, pl. 26, figs. 8a-f.
Climacograptus bicornis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 425, pl. 72, figs. 44–52.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood and they all have stout spines up to 1 cm long projecting from th1[1] and th1[2].

Horizon.—*C. bicornis* is a characteristic species in the upper beds of the Woods Hollow shale, zone 12 (collections 87, 94A, 103, and 136), and it is confined to that zone in the Marathon succession. Ruedemann records it from the Normanskill shale in New York and the writer has seen it at the University of Oklahoma in Decker's collections from the Womble shale of Arkansas and the Stringtown shale of Oklahoma. Elles and Wood state that "*C. bicornis* is an exceedingly abundant fossil in the Glenkiln and lower Hartfell shales" where it ranges from the zone of *Nemagraptus gracilis* through the zones of *Climacograptus peltifer* and *C. wilsoni* into the zone of *Dicranograptus clingani*. Thomas and Keble (1933) record *C. bicornis* as a common species in the Gisbornian and Eastonian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS CAUDATUS Lapworth

Pl. 18, fig. 7

Climacograptus caudatus Lapworth, 1876, Cat. West. Scottish Foss., p. 6, pl. 2, fig. 48.
Climacograptus caudatus Elles and Wood, 1906, Mon. British Grapt., pp. 202–203, text figs. 133 a-d, pl. 27, figs. 7a-e.
Climacograptus caudatus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 424, pl. 71, figs. 51–52, pl. 72, figs. 57–65.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood.

Horizon.—Specimens of *C. caudatus* were collected from the lower and middle parts of the Maravillas chert, zones 13 and 14 (collections 128 and 132). Ruedemann reports the species in the Magog shale at Magog, Quebec, in the lower part of the Viola limestone in Oklahoma, and in the upper part of the Womble shale near Crystal Springs, Arkansas. Elles and Wood record the species from the zone of *Dicranograptus clingani* in the Hartfell shales in southern Scotland and Ireland, and Harris and Thomas (1938b) figure it as one of the characteristic forms in the Eastonian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS EXIMIUS Ruedemann

Climacograptus putillus mut. *eximius* Ruedemann, 1908, New York State Mus. Mem. 11, p. 420, figs. 378–384, pl. 28, fig. 16.
Climacograptus eximius Ruedemann, 1925, New York State Mus. Bull. 262, p. 62.
Climacograptus eximius Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 435, pl. 72, figs. 1–15.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description.

Horizon.—Specimens of *C. eximius* are common in the Woods Hollow shale, zones 11 and 12 (collections 94A, 103, 137, and 139). Ruedemann states that the species is common in the Normanskill shale in New York, and the writer has seen it in Decker's collections from the Stringtown shale of Oklahoma and the Womble shale of Arkansas.

CLIMACOGRAPTUS HASTATUS T. S. Hall

Pl. 20, fig. 11

Climacograptus hastata T. S. Hall, 1902, Geol. Survey, New South Wales, p. 5, pl. 14, figs. 1–3.
Climacograptus hastatus T. S. Hall var. *americanus* Ruedemann, 1947 (pars), Geol. Soc. America Mem. 19, p. 427, pl. 73, figs. 8, 9, 13, 17, 19, not figs. 1–7, 10–12, 14–16, 18, 20.
Climacograptus tridentatus Sherrard, 1949, Linnean Soc. New South Wales, Proc., vol. 74, p. 69, text fig. 12A.
Climacograptus hastatus Harris and Thomas, 1955, Min. and Geol. Journ., vol. 5, no. 6, p. 39, figs. 8, 9.

Remarks.—The Texas specimens agree closely with the specific description by T. S. Hall. The Texas specimens have two, three, and even four basal spines (excluding the virgella projection). Sherrard (1949), on Dr. G. L. Elles' identifications, regards Hall's species as a synonym of *C. bicornis* var. *tridentatus*. However, none of the published figures nor descriptions of *C. bicornis* var. *tridentatus* record a virgellar projection which subordinates the two lateral spines. In all of Elles and Wood's (1906, pl. 26, figs. 9a-c) figures of *C. bicornis* var. *tridentatus*, the spines are thickened by membrane and are wider than the virgellar projection. In *C. hastatus* the virgellar projection is the prominent feature and the spines are subordinate. Ruedemann (1947) includes in his figures of *C. hastatus* var. *americanus* forms which may be related to *C. bicornis* (pl. 73, figs. 14, 15, 16, 18, 20) and some which show no development of spines (pl. 73, figs. 1–4). Even immature forms of the Texas specimens have spines. The writer considers that Ruedemann's figures 13, 17, and 19 (pl. 73) of *C. hastatus* var. *americanus* agree with the specific description of *C. hastatus* by Harris and Thomas, and thus the varietal name may not be needed.

Horizon. — Specimens of *C. hastatus* were collected from the highest beds of the Maravillas chert, zone 15 (collection 60). Ruedemann recorded his variety from the highest Ordovician horizon near Trail Creek, Blaine County, Idaho. Harris and Thomas record the species from the Eastonian series of the Upper Ordovician in Victoria, Australia. The species appears earlier in the Victorian sequence than it does in the Marathon.

CLIMACOGRAPTUS MINIMUS (Carruthers)

Pl. 19, fig. 2

Diplograptus minimus Carruthers, 1868, Geol. Mag., vol. 5, p. 125, pl. 5, figs. 12a, b.
Climacograptus minimus Elles and Wood, 1906, Mon. British Grapt., pp. 191–192, text figs. 124a-d, pl. 27, figs. 1a-g.

Remarks. — The rhabdosomes of the Texas specimens are small, the largest measuring 1.5 cm in length and 1.8 mm in breadth. Elles and Wood give a range in length of 1 to 3 cm and a maximum breadth of 2 cm for the English specimens. The thecae of the Texas specimens number 12 to 14 in 10 mm and their apertural margins are horizontal. Their excavations are not so deep as in the English specimens. The thecal excavations in the English forms occupy fully one-third of the width of the rhabdosome, whereas in the Texas specimens they occupy only about one-fourth the width of the rhabdosome. Elles and Wood give a thecal range of 11 to 14 in 10 mm for the English material. In the character of the proximal end and of the thecae, the Texas specimens agree with the description by Elles and Wood. In the writer's opinion, the Texas specimens, although small, appear to fall within the range in variation of *C. minimus*.

Horizon.—*C. minimus* is a common form in the middle part of the Maravillas chert, zone 14 (collections 54, 55, 83A, 83B, and 86A). Elles and Wood record the species from the zones of *Dicranograptus clingani* and *Pleurograptus linearis* of the Hartfell shales in southern Scotland and

Wales, and Thomas and Keble (1933) list it from the Eastonian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS MISSISSIPPIENSIS Ruedemann

Pl. 20, fig. 9

Climacograptus mississippiensis Ruedemann, 1908, New York State Mus. Mem. 11, pp. 413–414, text figs. 366, 367, pl. 28, figs. 12, 13.
Climacograptus mississippiensis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 431–432, pl. 74, figs. 3–9.

Remarks.—The Texas specimens agree closely with Ruedemann's specific description.

Horizon.—Specimens of *C. mississippiensis* were collected from the highest beds of the Maravillas chert, zone 15 (collections 60 and 138). Ruedemann's types came from the Sylvan shale of the Arbuckle Mountains in Oklahoma, and Ruedemann also records it from the Polk Creek shale and the Bigfork chert in Arkansas.

CLIMACOGRAPTUS MODESTUS Ruedemann

Climacograptus modestus Ruedemann, 1908, New York State Mus. Mem. 11, pp. 432–433, text figs. 400–403, pl. 28, fig. 30.
Climacograptus modestus Ruedemann, 1947, Geol. Soc. America Mem. 19, p 432, pl. 73, figs. 32–46.
Climacograptus modestus Bulman, 1948, Geol. Mag., vol. 85, pp. 222–223, text figs. 1a, b.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description. The more closely set thecae (16 in 10 mm in the Texas specimens) and the blunt, squarish appearance of the proximal end distinguish this species from *C. scharenbergi.*

Horizon.—Specimens of *C. modestus* were collected from the upper part of the Woods Hollow shale, zone 12 (collections 94A, 94B, and 94C). Ruedemann records the species from the Normanskill shale in New York, the upper part of the Womble shale in Arkansas, and from the "Athens shale" in Virginia and Tennessee. Bulman reports it with *Nemagraptus gracilis* from the Rorrington flags on Sky Brook, Shropshire.

CLIMACOGRAPTUS MODESTUS var. MERIDIONALIS Ruedemann

Climacograptus modestus var. *meridionalis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 433, pl. 73, figs. 47, 48.

Remarks.—The Texas specimens agree closely with Ruedemann's description except that the thecae number 14 in 10 mm, while in the type material the thecae number 10 to 13 in 10 mm.

Horizon.—Specimens of this variety were collected from the lower part of the Woods Hollow shale, zone 11 (collection 137). Ruedemann's types came from the "Athens shale" near Bristol, Tennessee, and he also reports it from the "Athens shale" near Calera, Alabama. The form occurs with *Nemagraptus gracilis* and its associates in Texas, Tennessee, and Alabama.

CLIMACOGRAPTUS PARVUS Hall

Pl. 16, fig. 12

Climacograptus parvus Hall, 1865, Canadian Organic Remains, p. 57 (nom. nud.).
Climacograptus parvus Hall, 1868, New York State Cab. Nat. Hist., 20th Ann. Rept., p. 224.
Climacograptus parvus Ruedemann, 1947, Geol. Soc. America Mem. 19. pp. 433–434, pl. 74, figs. 10–26.

Remarks.—The rhabdosomes of the Texas specimens are small, up to 20 mm long and 1.7 mm wide, but these measurements fall within the range in variation given by Hall in his specific description. The Texas specimens agree well with Hall's specific description in all other characters.

Horizon.—*C. parvus* was collected from zones 11 (collection 137) and 12 (collections 94A, 94B, and 136) in the Woods Hollow shale. The species is one of the most common and widespread graptolites in the upper part of the Middle Ordovician in North America. Ruedemann records it from the Normanskill shale in New York, the Stringtown shale of Oklahoma, the Womble shale of Arkansas, and from localities in Newfoundland, Maine, Virginia, Nevada, and Washington.

CLIMACOGRAPTUS PUTILLUS (Hall)

Graptolithus putillus Hall, 1865, Canadian Organic Remains, pp. 27, 44, pl. A, figs. 10–12a.

Climacograptus putillus Ruedemann, 1925, New York State Mus. Bull. 262, p. 60.
Climacograptus putillus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 434–435, pl. 72, figs. 29–42.

Remarks.—The Texas specimens are small, 5 to 7 mm in length and 1 mm wide, but still fall within the range of the measurements given by Ruedemann (1947) for *C. putillus*. In number of thecae (12 to 14 in 10 mm) and in character of the thecae, the Texas specimens agree with the description by Ruedemann.

Horizon.—Specimens of *C. putillus* were collected from the uppermost beds in the Maravillas chert, zone 15 (in collections 60 and 147). Ruedemann records it from the Maquoketa shale near Maquoketa, Iowa, and from the Sylvan shale of Oklahoma.

CLIMACOGRAPTUS RIDDELLENSIS Harris

Pl. 14, figs. 9, 10

Climacograptus riddellensis Harris, 1924, Royal Soc. Victoria, Proc. (n.s.), vol. 36, pp. 100–101, pl. 8, figs. 11, 12.

Remarks.—The Texas specimens agree well with the specific description by Harris except that the thecae number 11 to 12 in 10 mm while in the Australian specimens they number 10 to 11 in 10 mm and, rarely, as many as 13 in 10 mm. The characteristic wide, semicircular thecal excavations can easily be seen in the specimens preserved in low relief in limestone.

Horizon.—Specimens of *C. riddellensis* were collected from the basal beds of the Woods Hollow shale, zone 10 (collections 46 and 46A), and from higher in the same formation in zone 11 (collection 137). Harris (1935) lists the species as a common form in the zone of *Glyptograptus teretiusculus*, the highest zone in the Middle Ordovician of the Victoria, Australia, sequence. Thomas and Keble (1933) list it as present in collections from the Gisbornian series of the Victorian Upper Ordovician as well. The species has a similar range (zones of *G. teretiusculus* and *Nemagraptus gracilis*) in both the Marathon and Victorian successions.

CLIMACOGRAPTUS SCALARIS var. MISERABILIS Elles and Wood?

Remarks.—The Texas specimens are poorly preserved and some details can not be seen. The rhabdosomes agree with Elles and Wood's (1906, Mon. British Grapt., pp. 186–187, text figs. 120a-c, pl. 26, figs. 3a-h) description in size (1 to 1.5 cm in length and no more than 1 mm in breadth), in number of thecae (10 to 11 in 10 mm), and in possessing a complete septum. The thecae have vertical outer edges and horizontal apertural margins, which agree with Elles and Wood's description, but the size and shape of the excavations are obscure. Also, the nature of the proximal end is obscure. The Texas specimens agree with the description of *C. scalaris* var. *miserabilis* in general aspect, but the preservation is so poor that they are only tentatively referred to this variety.

Horizon.—Specimens provisionally referred to *C. scalaris* var. *miserabilis* were collected from one locality (collection 147) which is in the highest beds of the Maravillas chert, zone 15. They are associated with *Dicellograptus complanatus* and *D. complanatus* var. *ornatus*. Elles and Wood state that the variety *miserabilis* is most abundant in the zone of *Dicellograptus complanatus* and that it is also found in the zone of *Dicellograptus anceps* and a few individuals survive into the lowest beds of the Silurian. Thomas and Keble (1933) list the variety *miserabilis* from the highest beds of the Bolindian series of the Upper Ordovician of Victoria, Australia.

CLIMACOGRAPTUS SCHARENBERGI Lapworth

Climacograptus scharenbergi Lapworth, 1876, Cat. West. Scottish Foss., p. 6, pl. 5, fig. 35.
Climacograptus scharenbergi Elles and Wood, 1906, Mon. British Grapt., pp. 206–208, text figs. 139a-c, pl. 27, fig. 14a-e.
Climacograptus scharenbergi Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 438–439, pl. 74, figs. 41–54.
Climacograptus scharenbergi Bulman, 1947, Caradoc (Balclatchie) Grapt., pp. 65–70, text figs. 34–38, pl. 7, figs. 1–10, pl. 8, figs. 1, 5–7.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood.

Horizon.—Specimens of *C. scharenbergi* were collected from the lower part of the Maravillas chert, zone 13 (collections 73, 134, and 134A). Ruedemann records the species from the Normanskill shale in New York and the Magog shale in Quebec. Elles and Wood state that it is a long-ranging species in the British Isles, ranging from the zone of *Didymograptus bifidus* in the upper part of the Arenig series through the zone of *Climacograptus wilsoni* in the lower part of the Hartfell shales. The maximum number of individuals was collected from the younger horizons.

CLIMACOGRAPTUS SCHARENBERGI cf. var. STENOSTOMA Bulman

Pl. 15, fig. 6

Climacograptus scharenbergi var. *stenostoma* Bulman, 1947, Caradoc (Balclatchie) Grapt., p. 70, pl. 7, figs. 11, 12, pl. 8, figs. 2–4, 8.

Remarks.—The Texas specimens have smaller dimensions than the types. The largest of the Texas forms is 7 mm in length and has a maximum width of 0.9 mm compared to a length of 7 mm and a maximum width of 1.1 mm for the largest of the English specimens. The free ventral edges of the thecae show the same amount of curvature as do the English specimens, but the detail of the apertural excavations is obscure because of the poor preservation. The thecae number 14 to 15 in 10 mm in the Texas specimens, while they are somewhat less closely set in the English material. The Texas specimens are definitely of the *C. scharenbergi* type and agree in general aspect with Bulman's variety *stenostoma* but are slightly smaller and are not well enough preserved to reveal all the detail of the thecae.

Horizon.—Specimens of this form were collected from the Woods Hollow shale, zones 11 and 12 (collections 122, 127, and 150). Bulman's types of *C. scharenbergi* var. *stenostoma* came from the Balclatchie beds of Caradoc age exposed in Laggan Burn, Ayrshire, Scotland.

CLIMACOGRAPTUS SPINIFERUS Ruedemann

Climacograptus typicalis mut. *spinifer* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 411–412, text fig. 236, pl. 28, figs. 8, 9.

Climacograptus spiniferus Ruedemann, 1912, New York State Mus. Bull. 162, p. 84.

Climacograptus spiniferus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 439, pl. 75, figs. 1–7.

Remarks.—The Texas specimens agree fully with Ruedemann's specific description.

Horizon.—Specimens of *C. spiniferus* were collected from the lower part of the Maravillas chert, zone 13 (collections 86B and 134). Ruedemann states that this species is a common and characteristic form in the Canajoharie shale in New York, and that it also occurs in the Snake Hill shale and Schenectady beds in the same State and in the lower part of the Viola limestone in the Arbuckle Mountains of Oklahoma.

CLIMACOGRAPTUS TUBULIFERUS Lapworth

Pl. 19, fig. 5

Climacograptus tubuliferus Lapworth, 1876, Cat. West. Scottish Foss., pl. 2, fig. 49.

Climacograptus tubuliferus Elles and Wood, 1906, Mon. British Grapt., pp. 203–204, text figs. 134a-c, pl. 27, figs. 8a-d.

Climacograptus tubuliferus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 440, pl. 75, figs. 54–56.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood.

Horizon.—Specimens of *C. tubuliferus* were collected from the middle part of the Maravillas chert, zone 14 (collections 45, 55, 83B, 86A, and 93). Ruedemann records the species from the Polk Creek shale and the Talihina chert in Oklahoma. Elles and Wood report the species to be fairly common in the zone of *Pleurograptus linearis* and to be rare in the zone of *Dicranograptus clingani* in the British Isles. Thomas and Keble (1933) list *C. tubuliferus* from the Eastonian series of the Upper Ordovician in Victoria, Australia. The same species occurs with the same associates (*Orthograptus quadrimucronatus, Dicellograptus forchammeri,* and *Orthograptus truncatus*) in the Marathon, Victorian, and British sequences.

CLIMACOGRAPTUS TYPICALIS Hall

Climacograptus typicalis Hall, 1865, Canadian Organic Remains, pp. 27, 28, 57, pl. A, figs. 1–9.

Climacograptus typicalis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 440–441, pl. 75, figs. 27–38, not pl. 91, fig. 8.

Remarks.—The Texas specimens are all small yet still fall within the measurements given in the description by Ruedemann. The largest specimens measure 3.0 cm in length and 2.2 mm in width. The thecae in all of the Texas specimens number 11 to 13 in 10 mm and agree with the description of the type material.

Horizon.—*C. typicalis* was collected from the lower and middle parts of the Maravillas chert, zones 13 and 14 (collections 73, 131A, and 133). Ruedemann records the species from the Utica and Frankfort shales in New York, the Eden shale at Covington, Kentucky, the Platteville and Galena limestones of Minnesota, the lower part of the Viola limestone of Oklahoma, and the Womble shale of Arkansas.

CLIMACOGRAPTUS TYPICALIS var. CRASSIMARGINALIS Ruedemann and Decker

Pl. 17, figs. 1, 2

Climacograptus typicalis var. *crassimarginalis* Ruedemann and Decker, 1934, Jour. Paleont., vol. 8, pp. 322–323, 325, pl. 43, figs. 8, 9, 12, 12a.
Climacograptus typicalis var. *crassimarginalis* Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 441–442, pl. 73, figs. 23–26, pl. 75, fig. 46, pl. 91, fig. 8.

Remarks.—The Texas specimens of this spined variety of *C. typicalis* are all small and no complete rhabdosomes were found. However, the measurements of them do fall within the range of variation of *C. typicalis*, and the diagnostic character of this variety, the sharp flange that projects out from each thecae, is well developed. One of the forms figured by Ruedemann and Decker as *Amplexograptus amplexicaulis* from the Viola limestone (Ruedemann and Decker, 1934, pl. 42, figs. 1, 1a) should be referred to this variety of *C. typicalis*.

Horizon.—This form is a characteristic element of zone 13, the lower part of the Maravillas chert (collections 106, 128, 133, and 135). It is common in the lower part of the Viola limestone in the Arbuckle Mountains in Oklahoma, and it has been recorded from the Platteville limestone near Dixon, Illinois (Ruedemann, 1947).

CLIMACOGRAPTUS cf. C. ULRICHI Ruedemann

Remarks.—The Texas specimens tentatively referred to the species *C. ulrichi* are poorly preserved so that details of the thecae cannot be seen. The rhabdosomes are small, 10 to 12 mm in length, and 1.5 to 1.8 mm in width. The sicula end is narrow and pointed, and a free prolongation of the nemacaulis is present. The thecae number 10 to 12 in 10 mm. In all of these measurements, the Texas specimens agree with Ruedemann's description (1947, Geol. Soc. America Mem. 19, p. 443, pl. 91, figs. 9–12). However, the details of the thecae must be seen to identify the species definitely, and they cannot be seen in these specimens. Therefore, the Texas specimens can only be compared to *C. ulrichi*.

Horizon.—The specimens tentatively referred to *C. ulrichi* were collected from the uppermost beds of the Maravillas chert, zone 15 (collections 138 and 147). Ruedemann states that the species *C. ulrichi* is widely distributed throughout the Southwest. The type specimens were obtained by Ulrich from the Maquoketa shale at Spencer, Missouri, and Decker (1935, p. 708) has cited the species from the Sylvan shale of Oklahoma and the Polk Creek shale of Arkansas.

Subfamily DIPLOGRAPTINAE Lapworth, 1873

Genus DIPLOGRAPTUS McCoy, 1850

DIPLOGRAPTUS CRASSITESTUS Ruedemann

Pl. 20, figs. 7, 8

Diplograptus crassitestus Ruedemann, 1908, New York State Mus. Mem. 11, pp. 334–335, text figs. 299–300, pl. 25, fig. 6.
Diplograptus (Mesograptus) crassitestus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 415–416, pl. 71, figs. 3–9.

Remarks.—The Texas specimens are nearly identical to the type specimens from Oklahoma except that the length and width are slightly less. The rhabdosomes have a length of 32 to 38 mm with a width at the distal end of 1.3 to 1.8 mm. The thecae of

the Texas specimens number 9 to 10 in 10 mm, whereas the thecae number 7 to 10 in 10 mm in the type material.

Horizon.—This species is common in zone 15 (collections 60, 138, and 147), the highest beds of the Maravillas chert. The species is also common in the Sylvan shale in the Arbuckle Mountains in Oklahoma and in the Polk Creek shale in the Ouachita Mountains in Arkansas.

DIPLOGRAPTUS MULTIDENS Elles and Wood

Pl. 16, fig. 2; Pl. 19, fig. 6

Diplograptus (Mesograptus) multidens Elles and Wood, 1907, Mon. British Grapt., pp. 261–262, text fig. 178, pl. 31, figs. 9a-d.
Diplograptus (Mesograptus) multidens Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 420, pl. 71, figs. 15, 16.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood.

Horizon.—Specimens of *D. multidens* were collected from one locality (collection 87) which is in the upper part of the Woods Hollow shale, zone 12. It is associated with *Climacograptus bicornis, Orthograptus calcaratus* var. *acutus,* and *Amplexograptus* cf. *A. perexcavatus.* Elles and Wood record *D. multidens* from the highest beds of the Glenkiln shale and the lowest of the Hartfell shale, where it occurs with the same associates as in the Marathon region. Harris and Thomas (1938b) figure the species as one of the common forms in the Gisbornian series and state that it is one of the characteristic species of the upper part of that series in Victoria, Australia.

DIPLOGRAPTUS MULTIDENS var. DIMINUTUS Ruedemann

Diplograptus (Mesograptus) multidens var. *diminutus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 420, pl. 71, figs. 20–23.

Remarks.—The Texas specimens agree well with Ruedemann's description of this small variety. None of the rhabdosomes measure more than 15 mm in length and 1.8 mm in width. Except for the size dimensions, all characters of the variety are the same as those of the typical form.

Horizon.—Specimens of this variety were collected from the upper part of the Woods Hollow shale, zone 12 (collections 87, 94A, and 94C), where it is associated with the typical form of the species and with *Amplexograptus* cf. *A. perexcavatus* and *Orthograptus calcaratus* var. *acutus.* Ruedemann described the variety from "Ordovician shale of Normanskill age" at the southwest feeder of Portland Creek Pond, Newfoundland.

DIPLOGRAPTUS MINUTUS Berry, n. sp.

Pl. 18, figs. 2, 3

Description.—The rhabdosomes are small, measuring 10 to 14 mm in length and 1.1 mm in width at the proximal end but widening to 2.0 mm distally. The sicula was not observed. The proximal end is rounded and possesses a short virgella. A septum begins between the fifth and sixth thecal pair. The thecae number 11 to 12 in 10 mm, have a *Climacograptus* aspect in the proximal region of the rhabdosome and a gentle sigmoid curvature in the distal part. They overlap one-third to one-half their length and have wide apertural margins.

Horizon.—Specimens of this species were obtained from the upper part of the Maravillas chert, zone 14 (collection 45).

Holotype.—Yale Peabody Museum No. 20256.

Genus AMPLEXOGRAPTUS Elles and Wood, 1907

AMPLEXOGRAPTUS CONFERTUS (Lapworth)

Pl. 14, figs. 1, 2

Climacograptus confertus Lapworth, 1875, Quart. Jour. Geol. Soc., vol. 31, p. 655, pl. 34, figs. 4a-f.
Diplograptus (Amplexograptus) confertus Elles and Wood, 1907, Mon. British Grapt., pp. 269–270, text figs. 185a-c, pl. 31, figs. 18a-e.
Amplexograptus confertus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 300–301, fig. 1, nos. 14a, b, fig. 3, nos. 21–26.

Remarks.—The Texas specimens agree with the description of the Australian forms by Harris and Thomas. However, the thecae are fewer (14 to 10 in 10 mm) than in the English types (16 to 12 in 10 mm). Some of the Texas specimens are

preserved in low relief in limestones, and in these, the apertural excavations are slightly wider and not quite so deep as in the British types which are preserved flattened in shale. These slight variations may be due to the differences in preservation. The details of the thecae of the Texas specimens which are preserved flattened agree with the figures of the thecae of the British material. The thecae of the Texas specimens are fewer than the British types, but in most of the specimens the number of thecae fall within the range of variation of the number of thecae per 10 mm given by Elles and Wood. Therefore, the writer includes his forms under the species *A. confertus*.

Horizon.—Specimens of *A. confertus* were collected from zone 10, the highest beds of the Fort Peña formation and the lowest beds of the Woods Hollow shale (collections 38, 46, 46A, 81, 85, and 92). *A. confertus* is a diagnostic element of zone 10. Harris (1935) lists the species as common in the zone of *Diplograptus decoratus* of the Middle Ordovician of Victoria, Australia. Elles and Wood record it from the zone of *Didymograptus bifidus* (Lower Llanvirn) in Great Britain. The species occurs much earlier in the British sequence than it does in the Marathon and Australian sequences.

AMPLEXOGRAPTUS cf. A. DIFFERTUS Harris and Thomas

Remarks.—None of the rhabdosomes of the Texas specimens is longer than 1.5 cm, and they attain a width of 2.0 mm at a distance of 7.0 mm from the proximal end and widen to 2.5 mm at a distance of 10 mm from the proximal end. The thecae number 12 to 14 in 10 mm. The Texas specimens are not so long as the maximum length of the forms described by Harris and Thomas (1935, Royal Soc. Victoria, Proc. (n. s.), vol. 47, p. 301, fig. 1, no. 15, fig. 3, nos. 27–31), and the thecae are slightly closer packed (12 to 14 in 10 mm, whereas they number 10 to 13 in 10 mm in the Australian material). The Texas specimens agree in the character of the thecae with the description of those of *A. differtus* (the apertures are inclined with notably thickened margins and they occupy one-third the width of the rhabdosome and one-fourth of the free edge). Although the Texas specimens are slightly smaller and have slightly closer packed thecae, they agree in all other respects with *A. differtus* and should be compared to it.

Horizon.—A few specimens of this form were collected from zone 10. It was identified in collection 46 from the basal beds of the Woods Hollow shale and in collection 85 from the highest beds of the Fort Peña formation. Harris and Thomas report the species to be common in the zone of *Diplograptus decoratus* in the Middle Ordovician in Victoria, Australia.

AMPLEXOGRAPTUS cf. A. PEREXCAVATUS (Lapworth)

Pl. 16, figs. 8, 13

Remarks.—The Texas specimens are poorly preserved and the proximal ends cannot be seen. The fragments of the rhabdosomes seen are short and broad, 1 to 2 cm in length and 2.2 to 2.7 mm in breadth. The thecae number 12 to 14 in 10 mm, whereas Elles and Wood (1907, p. 267) give a range of 12 to 16 in 10 mm for the British specimens. In the reverse aspect the thecae appear similar to those of *Orthograptus*. In this view, the thecal overlap is conspicuous. The ventral wall extends almost to the center of the rhabdosome and the thecae may be seen to overlap for one-half their length. Also, the alternating arrangement of the thecae is clear. In size and shape of the rhabdosome and in number and character of the thecae, the Texas specimens agree with the specific description of *A. perexcavatus* by Elles and Wood (1907, Mon. British Grapt., pp. 267–269, text figs. 184a-d, pl. 31, figs. 15a-d), but since the proximal ends cannot be seen, definite specific identification is not warranted.

Horizon.—The specimens tentatively referred to *A. perexcavatus* were collected from the highest beds in the Woods Hollow shale, zone 12 (collection 87). Elles and

Wood report that *A. perexcavatus* is a very abundant fossil in the Glenkiln shales of Scotland and Wales, where it ranges from the zone of *Nemagraptus gracilis* to the zone of *Climacograptus wilsoni*. Elles (1925) lists it as a common fossil in the zone of *Climacograptus bicornis* var. *peltifer* where it is associated with *C. scharenbergi, Dicellograptus sextans,* and *Orthograptus calcaratus* var. *acutus*. The Texas specimens tentatively referred to *A. perexcavatus* were found in a similar assemblage. Harris and Thomas (1938b) figure *A. perexcavatus* as a common form in the Gisbornian series of the Upper Ordovician of Victoria, Australia.

Genus GLYPTOGRAPTUS Lapworth, 1873

GLYPTOGRAPTUS cf. G. AUSTRODENTATUS (Harris and Keble)

Pl. 13, figs. 2, 3

Remarks.—The rhabdosomes of the Texas specimens are longer and thinner than the Australian form described by Harris and Keble (1932, text figs. 1–4, pl. 5, figs. 4–5), since they average about 1.5 cm in length and widen from 1.5 mm at the base to 1.8 mm distally, whereas in the Australian material the rhabdosomes average about 1.0 cm in length and widen to 2 mm distally. The thecae in the Texas specimens number 14 in 10 mm, are 1.5 mm long and 0.3 mm wide, and overlap one-half their length. In the Australian forms, the thecae number 12 to 14 in 10 mm, are 1.5 mm long and 0.5 mm wide, and overlap one-half to two-thirds of their length. In all other respects the Texas specimens agree closely with the specific description of *G. austrodentatus* by Harris and Keble.

Horizon.—The forms tentatively referred to *G. austrodentatus* are rare in the lower part of the Fort Peña formation, zone 8 (collections 10, 95, 98A, and 112), and are common in the upper part of that formation, zone 9 (collections 15, 28, 117, 117A, and 152). In Australia *G. austrodentatus* is a common species in the lowest zone of the Middle Ordovician, and it is the name-giving species to that zone. It is associated with *Hallograptus etheridgei, Cryptograptus schaferi,* and *Trigonograptus ensiformis* in Australia, and the form herein tentatively referred to *G. austrodentatus* occurs with the same associates. A closely similar species, *G. dentatus,* is the characteristic form of graptolite bed 7 of the Deepkill shale in New York, and Raymond's (1914) zone D of the Levis shale in Quebec.

GLYPTOGRAPTUS INTERSITUS Harris and Thomas

Glyptograptus intersitus Harris and Thomas, 1935, Royal Soc. Victoria, Proc. (n.s.), vol. 47, pp. 296–297, fig. 1, nos. 11a-e, fig. 3, nos. 7–10.

Remarks.—The Texas specimens agree fully with the specific description by Harris and Thomas.

Horizon.—Specimens of *G. intersitus* were collected from the upper part of the Fort Peña formation, zone 9 (collections 13, 15, 16, and 28). In Victoria, Australia, the species is abundant in, and typical of, the second zone (to which it is the name-giving species) of the Middle Ordovician. It also occurs in the highest beds of the zone below (zone of *Glyptograptus austrodentatus*) and the lowest beds of the zone above (zone of *Diplograptus decoratus*).

GLYPTOGRAPTUS TERETIUSCULUS (Hisinger)

Pl. 14, figs. 3–5, 8; Pl. 16, fig. 5

Prionotus teretiusculus Hisinger, 1840, Lethaea Suecica, Suppl. II, p. 5, pl. 38, fig. 4.
Diplograptus (Glyptograptus) teretiusculus Elles and Wood, 1907, Mon. British Grapt., pp. 250–252, text figs. 171a-d, pl. 31, figs. 1a-e.
Diplograptus (Glyptograptus) teretiusculus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 408–409, pl. 69, figs. 35–45.

Remarks.—As Elles and Wood indicate, the rhabdosomes of *G. teretiusculus* display a considerable variation in shape. Many of the Texas specimens are thinner than the British types but agree in all other characters with the specific description by Elles and Wood. Some of the Texas specimens agree closely in all dimensions with Elles and Wood's specific description. Still others of the Texas specimens are wider than the British material but compare favorably in size with Swedish material. However, the

thecae of these latter Texas forms number but 9 in 10 mm while the thecae of the Swedish and English forms number 10 to 14 in 10 mm. The Texas specimens with wide rhabdosomes and fewer thecae have been identified as *G.* cf. *G. teretiusculus.*

Horizon.—*G. teretiusculus* is a common form in the Woods Hollow shale. It occurs in both zones 11 (collections 104, 137, and 150) and 12 (collections 87, 94C, 105, 127, and 136). The specimens referred to *G. teretiusculus* are the characteristic forms of zone 10 and give their name to that zone. They were collected from the uppermost beds of the Fort Peña formation (collections 81, 85, 92, and 126). *G. teretiusculus* is common in the Normanskill shale in New York according to Ruedemann, and he further states that it is known from the Womble shale in Arkansas, the Stringtown shale in Oklahoma, and localities in British Columbia, Nevada, New Jersey, Quebec, and Newfoundland. In Great Britain, the species is characteristic of horizon 8 (the zone of *G. teretiusculus*), but it ranges through zones 9 (zone of *Nemagraptus gracilis*) and 10 (zone of *Mesograptus multidens*) to zone 11 (zone of *Climacograptus wilsoni*). Harris (1935) lists *G. teretiusculus* as a very common species in the highest beds of the Middle Ordovician in Victoria, Australia, and it gives its name to a zone which comprises the youngest beds of the Victorian Middle Ordovician. Thomas and Keble (1933) record the species from the Gisbornian series of the Victorian Upper Ordovician. *G. teretiusculus* is a common and long-ranging species in the Marathon, Victorian and British graptolite sequences, and it is the characteristic form of the zone below that of *Nemagraptus gracilis* in all three areas.

GLYPTOGRAPTUS TERETIUSCULUS var. EUGLYPHUS (Lapworth)

Pl. 15, fig. 8

Diplograptus (Glyptograptus) euglyphus Lapworth, 1880, Ann. Mag. Nat. Hist., vol. 5, p. 166, pl. 4, figs. 14a-e.

Diplograptus (Glyptograptus) teretiusculus var. *euglyphus* Elles and Wood, 1907, Mon. British Grapt., p. 252, text fig. 172, pl. 31, figs. 2a-d.

Diplograptus (Glyptograptus) euglyphus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 405–406, pl. 69, figs. 46–50, 55–59.

Remarks.—The Texas specimens agree closely with the varietal description by Elles and Wood.

Horizon.—This variety is a fairly common fossil in the Woods Hollow shale. It is found in both zones 11 (collections 104, 148, and 150) and 12 (collections 87, 94A, 94B, 94C, 100, and 127). Elles and Wood state that the variety is fairly common in the zone of *Nemagraptus gracilis* in the Glenkiln shales of southern Scotland. Harris and Thomas (1935) refer a form to this variety which is common in the uppermost zone (zone of *G. teretiusculus*) of the Middle Ordovician of Victoria, Australia.

GLYPTOGRAPTUS TERETIUSCULUS var. PYGMAEUS (Ruedemann)

Diplograptus euglyphus var. *pygmaeus* Ruedemann, 1908, New York State Mus. Mem. 11, p. 371, text figs. 317, 318, pl. 25, fig. 24.

Diplograptus (Glyptograptus) euglyphus var. *pygmaeus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 406, pl. 69, figs. 51–53.

Remarks.—The Texas specimens agree closely with Ruedemann's figures of *Diplograptus (Glyptograptus) euglyphus* var. *pygmaeus.* The writer considers the form *G. euglyphus* to be a variant of *G. teretiusculus* and not a distinct species, and the forms Ruedemann considered to be varieties of *G. euglyphus* belong to the complex of forms related to *G. teretiusculus.* The variety *pygmaeus* is similar to the variety *euglyphus* except that the thecae number 14 to 15 in 10 mm (in var. *euglyphus* they measure 9 to 11 in 10 mm) and the rhabdosome is much thinner (0.9 to 1.4 mm wide whereas var. *euglyphus* is 1.4 to 2.2 mm in width).

Horizon.—Specimens of this variety were collected from the upper part of the Woods Hollow shale, zone 12 (collections 94A, 105, and 127). Ruedemann reports the species in the Normanskill shale at one locality near Lansingburg, New York, and from the Stringtown shale in Oklahoma.

GLYPTOGRAPTUS TERETIUSCULUS var. SICCATUS (Elles and Wood)

Diplograptus (Glyptograptus) teretiusculus var. *siccatus* Elles and Wood, 1907, Mon. British Grapt., p. 253, text figs. 173a, b, pl. 31, figs. 3a-d.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood.

Horizon.—Specimens of this variety were collected from one locality (collection 139) which is in the lower part of the Woods Hollow shale, zone 11. Elles and Wood state that the form is fairly common in the Glenkiln shales and their equivalents in the British Isles. It occurs associated with *Nemagraptus gracilis* and *Dicellograptus sextans* in both the Marathon and British sequences.

Genus ORTHOGRAPTUS Lapworth, 1873

ORTHOGRAPTUS CALCARATUS (Lapworth)?

Pl. 18, fig. 9

Remarks.—The rhabdosomes of the Texas specimens referred to this species are all broken. The longest fragment is 6 cm in length and is 3.0 mm in width. The specimens agree in size with Elles and Wood's (1907, Mon. British Grapt., pp. 239–241, text figs. 159a-c, pl. 30, figs. 1a-c) description of the species. They also agree with the description of *O. calcaratus* in character of the thecae, in number of the thecae (8 to 9 in 10 mm), and in the presence of a stout virgula tube. However, the proximal ends of the Texas specimens are not preserved, and since this is a characteristic portion of the rhabdosome of *O. calcaratus*, specific identification cannot be made without seeing it.

Horizon.—The specimens provisionally referred to *O. calcaratus* were collected from the middle part of the Maravillas chert, zone 14 (collections 83A, 131, and 131A). Ruedemann reports the species from the shale at Fall Creek, Hailey quadrangle, Idaho. Elles and Wood state that "*O. calcaratus* is a common fossil in the lower Hartfell shales in the zone of *Dicranograptus clingani*." Thomas and Keble (1933) list the species as present in the Eastonian and Bolindian series of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS CALCARATUS var. ACUTUS (Lapworth)

Pl. 16, figs. 3, 4

Diplograptus (Orthograptus) calcaratus var. *acutus* Lapworth, MS, 1890.
Diplograptus (Orthograptus) calcaratus var. *acutus* Elles and Wood, 1907, Mon. British Grapt., p. 242, text fig. 161, pl. 30, figs. 3a-c.
Diplograptus (Orthograptus) calcaratus var. *acutus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 399, pl. 68, figs. 14–19.

Remarks.—The Texas specimens agree fully with the specific description by Elles and Wood.

Horizon.—Specimens of this variety were collected from the upper part of the Woods Hollow shale, zone 12 (collections 87 and 94A). Ruedemann states that it is common in the Normanskill shale in New York and that it is also found in the "Athens shale" in Virginia. Elles and Wood record it from the Glenkiln shales in Scotland and Wales. The form occurs with the same associates (*Diplograptus multidens* and *Dicellograptus sextans*) in both the British and Marathon successions. Thomas and Keble (1933) list the variety *acutus* from the Eastonian and Bolindian series of the Upper Ordovician in Victoria, Australia. The form apparently appears in younger beds in the Australia sequence than it does in the British Isles or in the Marathon region.

ORTHOGRAPTUS CALCARATUS var. ALABAMENSIS (Ruedemann)

Diplograptus foliaceus var. *alabamensis* Ruedemann, 1908, New York State Mus. Mem. 11, p. 352, pl. 25, fig. 3.
Diplograptus (Orthograptus) calcaratus var. *alabamensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 399, pl. 68, fig. 20.

Remarks.—The Texas specimens agree closely with Ruedemann's description.

Horizon.—Specimens of this variety were collected from the upper part of the Woods Hollow shale, zone 12 (collections 94A, 100, and 127). Ruedemann's types came from the Athens shale at Pratts Ferry, Bibb County, Alabama. Decker (1952) records the species from several

localities in Alabama, Virginia, and Tennessee.

ORTHOGRAPTUS cf. O. CALCARATUS var. BASILICUS (Lapworth)

Pl. 19, fig. 3

Remarks.—The rhabdosomes of the Texas specimens are broken, but they agree in general form with the description by Elles and Wood (1907, Mon. British Grapt., p. 243, text figs. 162a, b, pl. 30, figs. 2a-d). The largest fragment of the Texas material measures 6 cm in length and 2.5 mm in breadth. The thecae number 10 to 12 in 10 mm, overlap one-half their extent, and have an average length of about 3 mm. The Texas specimens agree closely in size and shape and in number and character of the thecae with the description of *O. calcaratus* var. *basilicus* by Elles and Wood. However, in none of the Texas specimens are the proximal ends of the rhabdosomes preserved, and since the nature of the proximal end is a characteristic portion of the rhabdosome, specific identification is uncertain.

Horizon.—The specimens tentatively referred to *O. calcaratus* var. *basilicus* were collected from the middle part of the Maravillas chert, zone 14 (collections 54 and 83A). Elles and Wood state that the variety *basilicus* "occurs in fair abundance in the zones of *Dicranograptus clingani* and *Pleurograptus linearis*" of the Hartfell shales in Scotland and Wales. Thomas and Keble (1933) record the variety from the Eastonian and Bolindian series of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS CALCARATUS var. INCISUS (Lapworth)

Pl. 17, figs. 3, 7

Graptolithus pristis Hall, 1847, Paleontology of New York, vol. 1, p. 72, fig. 11.

Diplograptus foliaceus var. *incisus* Lapworth *in* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 347–349, text figs. 283–287, pl. 24, figs. 1–8.

Diplograptus (Orthograptus) calcaratus var. *incisus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 400, pl. 68, figs. 1–13, 24.

Remarks.—The Texas specimens are poorly preserved but agree with the description of this variety by Ruedemann in size (up to 4.5 cm in length and 3 mm in breadth), in number of thecae (8 to 9 in 10 mm), in inclination of the thecae (40 to 50 degrees to the nemacaulus), in character of the thecae, and in general shape of the rhabdosome.

Horizon.—Specimens of this variety were collected from the lower part of the Maravillas chert, zone 13 (collections 106 and 128). Ruedemann reports that this variety is common in the Normanskill shale in New York. The writer has observed it at the New York State Museum at Albany, New York, in collections from the Magog shale and at the University of Oklahoma in collections from the Stringtown shale of Oklahoma and the Womble shale of Arkansas.

ORTHOGRAPTUS cf. O. CALCARATUS var. VULGATUS (Lapworth)

Pl. 18, fig. 8

Remarks.—The Texas specimens agree with the description of this variety by Elles and Wood (1907, Mon. British Grapt., pp. 241–242, text figs. 160a-c, pl. 30, figs. 5a-d) in size, in the abrupt widening and general coarseness of the rhabdosome, and in the more everted character of the apertural margin of the thecae in subsclariform view. However, the thecae are rather sparse (8 in 10 mm compared to 8 to 10 in 10 mm in the British specimens), and the proximal ends are not preserved. Since the nature of the proximal end of the rhabdosome in this variety is an important characteristic, the Texas specimens can be referred to this species only tentatively.

Horizon.—Specimens referred to *O. calcaratus* var. *vulgatus* were collected from the lower and middle parts of the Maravillas chert, zone 13 (collections 134 and 134A) and zone 14 (collections 45 and 131A). Ruedemann (1947) records the variety *vulgatus* from the Magog shale in Quebec. Elles and Wood state that it is an abundant fossil in the lower part of the Hartfell shales of southern Scotland where it occurs in the zones of *Climacograptus wilsoni* and *Dicranograptus clingani*. The Texas forms occur in zone 13 of the Mara-

thon sequence with the same associates (*Dicranograptus nicholsoni* and *Orthograptus truncatus* var. *intermedius*) as does the variety *O. calcaratus* var. *vulgatus* in the zone of *Climacograptus wilsoni* in Scotland. The form ranges into the next higher zone in both the Marathon and British sequences. Thomas and Keble (1933) list *O. calcaratus* var. *vulgatus* from the Gisbornian and Eastonian series of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS QUADRIMUCRONATUS (Hall)

Pl. 18, fig. 1

Graptolithus quadrimucronatus Hall, 1865, Canadian Organic Remains, p. 144, pl. 13, figs. 1–10.
Diplograptus (Orthograptus) quadrimucronatus Elles and Wood, 1907, Mon. British Grapt., pp. 223–224, text figs. 145a-f, pl. 28, figs. 1a-d.
Glossograptus quadrimucronatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 452–454, pl. 78, figs. 1–5, not pl. 81, figs. 29–32.

Remarks.—The Texas specimens agree closely with the specific description by Elles and Wood. The rhabdosomes of this species do not have the long dorsal and lateral spines which characterize the genus *Glossograptus*, and the writer follows Elles and Wood in considering it to be an orthograptid in which the thecae are nearly rectangular in section and the apertural margins are slightly lobate and spinose.

Horizon.—Specimens of *O. quadrimucronatus* were first recognized in collections from the Marathon region by Ruedemann (*in* Sellards, 1933). The writer found the species to be a common form in the middle part of the Maravillas chert, zone 14 (collections 45, 55, 73A, 83A, and 83B). The species is a characteristic element of the fauna of zone 14 and gives its name to that zone. Ruedemann records the typical form of *O. quadrimucronatus* from the Atwater Creek shale in New York and from the Gloucester shale at Lake St. John in the Province of Quebec. Elles and Wood report the species to be a rather common form in the zone of *Pleurograptus linearis* in the Hartfell shales of southern Scotland. Harris and Thomas (1938b) report that *O. quadrimucronatus* is a common form in the basal part of the Bolindian series (zone of *Pleurograptus*) of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS QUADRIMUCRONATUS var. ANGUSTUS (Ruedemann)

Pl. 17, figs. 10a, 11

Glossograptus quadrimucronatus var. *angustus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 454, pl. 79, figs. 20–24.

Remarks.—Ruedemann's types of this slender variety came from the Maravillas chert in the Marathon region. Specimens collected by the writer are identical to those described by Ruedemann.

Horizon.—The writer found this variety of *O. quadrimucronatus* to be a common form in the lower part of the Maravillas chert, zone 13 (collections 73, 86B, and 134A).

ORTHOGRAPTUS QUADRIMUCRONATUS var. CORNUTUS (Ruedemann)

Glossograptus quadrimucronatus var. *cornutus* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 393–394, text figs. 338–342, pl. 27, figs. 8–10.
Glossograptus quadrimucronatus var. *cornutus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 455, pl. 78, figs. 23–31.

Remarks.—The Texas specimens agree closely with Ruedemann's description of this variety.

Horizon.—Specimens of this variety were collected from one locality (collection 134A) which is in the lower part of the Maravillas chert, zone 13. Ruedemann records the species from the Canajoharie shale near Albany, New York, and from the upper part of the Womble shale near Crystal Springs, Arkansas.

ORTHOGRAPTUS aff. O. TRUNCATUS (Lapworth)

Remarks.—The Texas specimens are poorly preserved and broken, so that the nature of the proximal end is difficult to see. However, the fragments of the rhabdosomes are up to 3 cm in length and 3 to 3.5 mm in breadth; they agree in size with the British material. Also, the thecae agree in number and in character with those of *O. truncatus* described by Elles and Wood (1907, Mon. British Grapt., pp. 233–235, text figs. 154a, b, pl. 29, figs. 3a-e). At the New York State Museum, the writer has

examined specimens which Ruedemann identified as *Amplexograptus amplexicaulis* and is of the opinion that all of them belong to the *Orthograptus truncatus* group. Most of the specimens should properly be referred to *O. truncatus* itself, but some belong to a distinct variety.

Horizon.—The specimens referred to *O. truncatus* were collected from the lower and middle parts of the Maravillas chert, zones 13 (collections 86B, 128, and 134) and 14 (collection 83A). Ruedemann (1947) records *Amplexograptus amplexicaulis* from the Maravillas chert, the Trenton limestone at Trenton Falls near Middleville, New York, the Snake Hill shale in New York, and the Viola limestone in Oklahoma. Elles and Wood state that *O. truncatus* is an abundant fossil in the zones of *Dicranograptus clingani* and *Pleurograptus linearis* of the Hartfell shales in the British Isles. Thomas and Keble (1933) list *O. truncatus* from the Eastonian and Bolindian series of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS TRUNCATUS var. ABBREVIATUS (Elles and Wood)?

Pl. 20, fig. 10

Remarks.—The Texas specimens are small and poorly preserved. The largest specimen is 9 mm in length and widens gradually to a width of 2 mm. The figures of the English types measure 2 mm in width 9 mm from the sicula. The thecae are like those of *O. truncatus* but widen conspicuously towards the aperture. In this respect they agree with Elles and Wood's description (1907, Mon. British Grapt., pp. 235–236, text figs. 155a-d, pl. 29, figs. 6a-e). However, the thecae appear to be inclined at a slightly higher angle to the stipe than in the English material, but this may be a matter of preservation. Further, the preservation is so poor that the details of the proximal end are obscure.

Horizon.—The specimens referred to this variety were collected from the highest beds of the Maravillas chert, zone 15 (collection 147). Elles and Wood report the variety to be characteristic of the highest beds of the Hartfell shales (zones of *Dicellograptus complanatus* and *D. anceps*) in the British Isles. The variety occurs with the same associates (*D. complanatus* and *O. truncatus* var. *socialis*) in both the Marathon and British sequences.

ORTHOGRAPTUS TRUNCATUS var. INTERMEDIUS (Elles and Wood)

Pl. 17, figs. 4, 5

Diplograptus (Orthograptus) truncatus var. *intermedius* Elles and Wood, 1907, Mon. British Grapt., p. 236, text figs. 156a, b, pl. 29, figs. 4a-e.

Remarks.—Some of the Texas specimens agree closely with Elles and Wood's description of this variety except that the thecae number 10 to 11 in 10 mm whereas Elles and Wood give a measure of 10 to 14 in 10 mm. Others of the Texas forms agree with Elles and Wood's description in size and in general form of the thecae, but they do not agree in number of thecae (8 to 9 in 10 mm) nor in the overlap of the thecae. These latter forms have been identified as *O. truncatus* cf. var. *intermedius*. Some of the specimens at the New York State Museum which were identified by Ruedemann as *Amplexograptus amplexicaulis* should, in the writer's opinion, be referred to *O. truncatus* var. *intermedius*, because these forms agree well with Elles and Wood's varietal description.

Horizon.—All specimens of this variety (including those referred to it) were collected from zone 13 which encompasses the lower part of the Maravillas chert. The form is a characteristic element of the fauna of zone 13. Good specimens of the variety were identified in collections 73, 86B, and 134A, and specimens referred to the variety were identified in collection 134. Ruedemann (1947) reports the variety from the McKenzie Mountains, North West Territory, Canada. Ruedemann's specimens identified as *A. amplexicaulis*, but which are *O. truncatus* var. *intermedius*, came from the Trenton limestone at Trenton Falls near Middleville, New York, and from the Snake Hill shale in New York. Elles and Wood state that "var. *intermedius* is especially char-

acteristic of the zone of *Climacograptus wilsoni*, and also occurs in the zone of *Dicranograptus clingani*" in the British Isles. Thomas and Keble (1933) list the var. *intermedius* from the Eastonian and Bolindian series of the Upper Ordovician in Victoria, Australia.

ORTHOGRAPTUS TRUNCATUS var. PERTENUIS (Ruedemann)

Diplograptus amplexicaulis var. *pertenuis* Ruedemann, 1908, New York State Mus. Mem. 11, pp. 365–366, text figs. 308–310, pl. 25, figs. 14–16.
Diplograptus (Amplexograptus) amplexicaulis var. *pertenuis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 412, pl. 70, figs. 16–22.

Remarks.—The Texas specimens agree closely with Ruedemann's description of the variety *pertenuis*. The writer has studied the type specimens of this variety at the New York State Museum and is of the opinion that it belongs to the *Orthograptus truncatus* group. Since it belongs to that group, but does not agree with any of the previously described varieties, it is herein considered to be another variety of *O. truncatus*.

Horizon.—Ruedemann (*in* Sellards, 1933) first reported the variety *pertenuis* from the Maravillas chert, and the writer collected it from the lower and middle parts of that formation, zones 13 (collection 134A) and 14 (collection 132). Ruedemann's type material came from the Snake Hill shale in New York.

ORTHOGRAPTUS TRUNCATUS var. RECURRENS (Ruedemann)

Pl. 18, figs. 4, 5

Diplograptus recurrens Ruedemann, 1925, New York State Mus. Bull. 262, pp. 58–59, text figs. 42–46, pl. 7, figs. 2–4.
Diplograptus (Amplexograptus) recurrens Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 414, pl. 70, figs. 40–50, 55.

Remarks.—The Texas specimens agree closely with Ruedemann's description. The writer has studied the type specimens of this form at the New York State Museum and is of the opinion that it belongs to the *Orthograptus truncatus* group. The form is close to the variety *pauperatus* but may be distinguished from it by the closer arrangement of the thecae and the smaller dimensions of the rhabdosome. The thecae number 13 to 16 in 10 mm in the variety *recurrens* and 12 to 14 in the variety *pauperatus*. Further, the rhabdosome of the variety *recurrens* is a maximum of 1.8 mm in width and 2.5 cm in length while the rhabdosome of the variety *pauperatus* measures a maximum of 2.0 mm in width and 6 cm in length. Because the variety *recurrens* is different from any previously described variety of *O. truncatus*, the writer considers it a distinct variety.

Horizon.—Specimens of this variety were collected from the middle part of the Maravillas chert, zone 14 (collections 45, 131A, and 132). Ruedemann records the form from the lower part of the Lorraine group (Whetstone Gulf formation) in New York and from the upper part of the Viola limestone in Oklahoma.

ORTHOGRAPTUS TRUNCATUS var. SOCIALIS (Lapworth)

Pl. 20, figs. 4–6.

Diplograptus socialis Lapworth, 1880, Ann. Mag. Nat. Hist., ser. 5, vol. 5, p. 166, pl. 4, figs. 13a-e.
Diplograptus (Orthograptus) truncatus var. *socialis* Elles and Wood, 1907, Mon. British Grapt., pp. 237–238, text figs. 157a-d, pl. 29, figs. 7a-e.

Remarks.—The Texas specimens are not well preserved but appear to agree with Elles and Wood's figures and description of this variety. The form described by Ruedemann (1947, p. 402, pl. 69, figs. 9–11) as *Diplograptus (Orthograptus) nexus* is an *Orthograptus* of the *truncatus* type and is quite similar to the variety *socialis*.

Horizon.—Specimens of this variety were collected from the highest beds in the Maravillas chert, zone 15 (collection 60). Elles and Wood report it to be common in the zone of *Dicellograptus complanatus* in the upper part of the Hartfell shales in the British Isles.

ORTHOGRAPTUS WHITFIELDI (Hall)

Pl. 16, fig. 7

Graptolithus whitfieldi Hall, 1859, Paleontology of New York, vol. 3, p. 516, fig. 1.

Diplograptus (Orthograptus) whitfieldi Elles and Wood, 1907, Mon. British Grapt., pp. 227–228, text figs. 149a, b, pl. 28, figs. 6a-d.
Glossograptus whitfieldi Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 457–458, pl. 77, figs. 23–26.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood. The rhabdosomes of this species do not have the long dorsal and lateral spines which characterize the genus *Glossograptus*, and the writer follows Elles and Wood in considering it to be an orthograptid in which the thecae are nearly rectangular in section and the apertural margins are slightly lobate and spinose.

Horizon.—Specimens of *O. whitfieldi* were collected from the upper part of the Woods Hollow shale, zone 12 (collections 94A, 105, and 127). Ruedemann records the species from the Normanskill shale in New York and from the Womble shale in Arkansas. Elles and Wood report it from the Glenkiln shales in the British Isles. It occurs in both continents with the same associates (*Diplograptus multidens*, *Dicellograptus sextans*, and *Climacograptus bicornis*).

Family ?DIPLOGRAPTIDAE Incertae Sedis

Genus **TRIGONOGRAPTUS Nicholson, 1869**

TRIGONOGRAPTUS ENSIFORMIS (Hall)

Pl. 12, fig. 10; Pl. 13, figs. 6, 7

Graptholithus ensiformis Hall, 1858, Canada Geol. Survey, Rept. Prog. for 1857, p. 133.
Trigonograptus ensiformis Elles and Wood, 1908, Mon. British Grapt., pp. 302–303, text figs. 202a-c, pl. 35, figs. 1a-c.
Trigonograptus ensiformis Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 447–448, pl. 76, figs. 49–57.

Remarks.—The rhabdosomes of the Texas specimens are smaller than the type forms in length and width but agree in all other details. The length of the Texas specimens ranges from 2 to 5 cm, with an average of about 3 cm, and the width ranges from 1.5 to 3 mm, with an average of about 2 mm. The thecae number 9 to 11 in 10 mm, are inclined at an angle of 45 degrees, and are in contact throughout their length.

Horizon.—*T. ensiformis* is common in the upper part of the Fort Peña formation, zone 9 (collections 13, 15, 28, and 98). A few specimens were found in the lower part of that formation, zone 8 (collection 62). The species is common in zone 3 (zone of *Diplograptus dentatus*) of the Deepkill shale in New York. Hall's types came from the Levis shale in Quebec, and Raymond (1914) lists it from his zone D (zone of *D. dentatus*) of that formation. Elles and Wood record *T. ensiformis* from the upper part of the Skiddaw slates in the British Isles, and Harris (1935) records it from the lower two zones of the Middle Ordovician in Victoria, Australia.

Family LASIOGRAPTIDAE Bulman, 1955

Genus **HALLOGRAPTUS Lapworth, 1877**

HALLOGRAPTUS BIMUCRONATUS (Nicholson)

Diplograptus bimucronatus Nicholson, 1869, Ann. Mag. Nat. Hist., ser. 4, vol. 4, p. 236, pl. 11, fig. 12.
Lasiograptus (Hallograptus) mucronatus var. *bimucronatus* Elles and Wood, 1908, Mon. British Grapt., pp. 323–324, text figs. 212a, b, pl. 33, figs. 8a-e.
Lasiograptus (Hallograptus) bimucronatus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 465, pl. 80, fig. 52, pl. 81, figs. 11–28.

Remarks.—This distinctive form was originally described by Nicholson as a distinct species, but Elles and Wood included it as a variety under *Lasiograptus (Hallograptus) mucronatus*. The writer is of the opinion that the differences are sufficient to distinguish the two forms as separate species. *H. bimucronatus* has closely set thecae (12 to 16 in 10 mm) whereas *H. mucronatus* has 8 to 10 thecae in 10 mm. The rhabdosomes of *H. bimucronatus* are medium sized, attaining a length of 5 cm or more, although specimens attaining a length of 3 cm are of most frequent occurrence. Mature forms are 3 mm wide. This width is attained 15 mm from the sicula. Rhabdosomes of *H. bimucronatus* are wider and longer than those of *H. mucronatus*. Further, the apertural spines in *H. bimucronatus* are thicker and diverge earlier than those of *H. mucronatus* so that the paired nature of the spines is nearly always seen, and some specimens of *H. bimucronatus* show distinct scopulate processes extending outward beyond the margin of the thecae. The Texas speci-

mens of *H. bimucronatus* agree in all respects with the description by Ruedemann of *Lasiograptus (Hallograptus) bimucronatus.*

Horizon.—H. bimucronatus was collected from the Woods Hollow shale, zones 11 (collection 137) and 12 (collection 94B). Ruedemann records the species from the Normanskill shale in New York and the Womble shale in Arkansas. Elles and Wood state that this form is fairly common in the zone of *Nemagraptus gracilis* of the Glenkiln shales in the British Isles. The species occurs with identical zonal assemblages in the British and Marathon successions.

HALLOGRAPTUS ECHINATUS (Ruedemann)

Glossograptus echinatus Ruedemann, 1904, New York State Mus. Mem. 7, pp. 725–726, text fig. 102, pl. 16, figs. 30–32.
Lasiograptus (Hallograptus) echinatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 462–463, pl. 77, figs. 9–12, 14, not figs. 13, 16.

Remarks.—The Texas specimens agree well with Ruedemann's specific description. The genus of this form is in some doubt, but the writer follows Ruedemann's last opinion and leaves the form in the genus *Hallograptus.* Bulman (1955) raised *Hallograptus* from subgeneric to generic status. The form from the Glenogle shale (fig. 13) is not the same species as the New York and Marathon forms.

Horizon.—This species was collected from zone 9, the upper part of the Fort Peña formation (collections 13, 42, 98, and 149). Ruedemann (*in* Sellards, 1933) first identified the species from the Marathon region, and his type material came from the *Diplograptus dentatus* zone of the Deepkill shale in New York.

HALLOGRAPTUS ETHERIDGEI (Harris)

Pl. 12, figs. 6, 9b; Pl. 13, fig. 4

Lasiograptus (Thysanograptus) etheridgei Harris, 1924, Royal Soc. Victoria, Proc. (n.s.), vol. 36, pp. 98–99, pl. 7, figs. 3–7.

Remarks.—The Texas specimens agree well with Harris' specific description except that the Texas specimens have a maximum width of 3 mm (exclusive of the external meshwork), while Harris records a maximum width of 4 mm. *H. etheridgei* resembles the British *L. costatus* but the British form has more closely set thecae (10 to 16 in 10 mm) and the main ribs of the meshwork originate from the mesial angles of the thecae and curve outward, then downward. The thecae number 9 to 11 in 10 mm in *H. etheridgei,* and the main ribs of the meshwork appear to arise from the aperture of the thecae and curve outward, then split with one part curving downward and the other curving upward. The main ribs of *H. etheridgei* are thicker than in the British form, and frequently the rhabdosomes and only the main ribs of the mesh are preserved and those ribs show the split at their distal end. The sicula is about 1 mm in length and in some specimens the virgella appears to be thickened and projects downward for 1 mm from the sicula. Theca 1^1 grows downward for the greater part of its length then bends upward in the region of the aperture and Th 1^2 appears to grow downward at first before bending upward; the proximal end has a cryptograptid aspect.

Horizon.—H. etheridgei is a common form in the upper part of the Fort Peña formation, zone 9 (collections 13, 14, 15, 117, and 149) and has been selected as the name-giving species of that zone. Harris (1935) lists it as very common in the zone of *Glyptograptus intersitus* of the Middle Ordovician of Victoria, Australia. The species occurs with the same associates (*Trigonograptus ensiformis, Glyptograptus intersitus,* and *Cryptograptus schaferi*) in both the Marathon and Victorian sequences.

HALLOGRAPTUS MUCRONATUS (Hall)

Pl. 16, fig. 6

Graptolithus mucronatus Hall, 1847, Paleontology of New York, vol. 1, p. 268, pl. 73, figs. 1a-d.
Lasiograptus (Hallograptus) mucronatus Elles and Wood, 1908, Mon. British Grapt., pp. 321–322, text figs. 210a, b, pl. 33, figs. 6a-e.
Lasiograptus (Hallograptus) mucronatus Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 463–464, pl. 81, figs. 1–9.

Remarks.—The Texas specimens agree fully with the specific description by Ruedemann.

Horizon.—Only a few specimens of this species were found, and they came from the upper part of the Woods Hollow shale, zone 12 (collections 87, 94A, and 94B). It is one of the commonest forms in the Normanskill shale in New York. Decker (1952) lists it from the Stringtown shale of Oklahoma and the Womble shale of Arkansas. Elles and Wood described it from the Glenkiln shales of Scotland, Wales, and Ireland. The forms listed as *Lasiograptus* (*Hallograptus*) *etheridgei* Harris from Victoria, Australia, are distinct species and are not synonymous with *Hallograptus mucronatus* as Ruedemann (1947) suggested.

Family RETIOLITIDAE Lapworth, 1873

Subfamily ARCHIRETIOLITINAE Bulman, 1955

Genus RETIOGRAPTUS Hall, 1859

RETIOGRAPTUS DECKERI Ruedemann

Retiograptus sp. Decker, 1935, Jour. Paleont., vol. 9, p. 708, fig. 21.
Retiograptus deckeri Ruedemann, 1947, Geol. Soc. America Mem. 19, pp. 458–459, pl. 80, figs. 33–41.

Remarks.—The Texas specimens are small but agree well with Ruedemann's specific description.

Horizon.—Specimens of *R. deckeri* were collected from the top of the Maravillas chert, zone 15 (collection 60). Ruedemann records the species from both the Polk Creek shale in Arkansas and the Sylvan shale in Oklahoma.

RETIOGRAPTUS GEINITZIANUS Hall

Pl. 15, fig. 3a

Retiograptus geinitzianus Hall, 1859, Paleontology of New York, vol. 3, p. 518.
Retiograptus geinitzianus Elles and Wood, 1908, Mon. British Grapt., pp. 316–317, text figs. 209a-c, pl. 34, figs. 7a-d.
Retiograptus geinitzianus Ruedemann, 1947. Geol. Soc. America Mem. 19, pp. 459–460, pl. 80, figs. 11–26.

Remarks.—The Texas specimens agree well with the specific description by Elles and Wood. Many of the specimens are fragmentary, but some whole rhabdosomes were found.

Horizon.—Fragments of this species are common in zones 11 and 12 (collections 94A, 122, 136, 137, and 139) and are common elements of the fauna of the Woods Hollow shale. Hall's types came from the Normanskill shale at Albany, New York, and the species has been recorded by Ruedemann from several other localities in the Normanskill shale. Ruedemann also reports it from the Womble shale in Arkansas, the "Athens" shale at Pratts Ferry, Alabama, and the Glenogle shale in British Columbia. Elles and Wood state that "*R. geinitzianus* is a rare fossil in the Glenkiln shales" of Scotland and Wales, and T. S. Hall (1920) listed the species from the Upper Ordovician of Victoria, Australia. The species is found with the same associates (*Nemagraptus gracilis, Dicellograptus sextans, Climacograptus antiquus*) in North America, England, and Australia.

RETIOGRAPTUS PULCHERRIMUS Keble and Harris

Pl. 17, figs. 9, 10b

Retiograptus pulcherrimus Keble and Harris, 1934, Nat. Mus. Melbourne Mem. 8, pp. 178–179, text fig. 6, pl. 22, fig. 1.

Remarks.—The Texas specimens agree fully with the specific description by Keble and Harris.

Horizon.—This species is a common form in the lower and middle parts of the Maravillas chert, zones 13 and 14 (collections 45, 55, 73, 83B, 86B, 132, 134, and 134A). Harris and Thomas (1938b) state that it is part of a distinct assemblage in the highest zone of the Upper Ordovician, Bolindian series in Victoria, Australia. The species occurs lower in the Marathon succession than it does in the Victorian.

RETIOGRAPTUS SPECIOSUS Harris?

Remarks.—The Texas specimens are poorly preserved, many are broken or bent, but they appear to agree with the description by Harris (1924, Royal Soc. Victoria, Proc. (n. s.), vol. 36, pp. 99–100, pl. 8,

figs. 8–10). The test has not been preserved in any of the specimens so that the clathria can be clearly seen.

Horizon.—The Texas specimens were collected from one locality (collection 13) which is in the upper part of the Fort Peña formation, zone 9. Harris and Thomas (1938b) figure *R. speciosus* as a common form in the Middle Ordovician in Victoria, Australia.

RETIOGRAPTUS TENTACULATUS (Hall)?

Remarks.—The Texas specimens are poorly preserved but appear to agree with the specific description by Ruedemann (1947, Geol. Soc. America Mem. 19, pp. 460–461, pl. 80, figs. 1–5, not figs. 6–10), except that the width is slightly less (3.5 mm whereas the New York material is 4.0 mm). The forms from the Glenogle shale (figs. 6–10) which Ruedemann included in this species are larger than the New York, Arkansas, and Texas forms, and they possess lacinia. They are a species distinct from *R. tentaculatus* and should probably be referred to *Hallograptus etheridgei.* Because the Texas specimens are poorly preserved and are slightly narrower than the types, the writer refers them provisionally to Hall's species.

Horizon.—The specimens tentatively referred to *R. tentaculatus* were collected from one locality (collection 98) which is in the upper part of the Fort Peña formation, zone 9. Hall's types came from the horizon with *Diplograptus dentatus* (Raymond's zone D) of the Levis shale in Quebec. Ruedemann records the species from the beds with *Diplograptus dentatus* in the Deepkill shale in New York and from the Glenogle shale in British Columbia.

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APPENDIX

I. Measured Sections

Following is a list of the measured sections from which fossils were collected. The stratigraphic position of the collections is indicated, and a list of species identified in each is given. Most of the sections were measured in the Marathon anticlinorium because the folding and faulting were found to be less intense. The majority of the section localities lie within the Monument Spring quadrangle, a few are in the Marathon quadrangle, and one is in the Santiago Peak quadrangle, as shown on Plate 1, a map compiled from topographic maps which cover the area of study. The sections have not been shown graphically because most of them were measured close together in one anticlinorium; the Maravillas chert was the only formation which could be accurately delimited in any of the exposures in the Dagger Flat anticlinorium or south of it.

SECTION I

Section 4 miles in a straight line southwest of Marathon, along a line bearing S. 65° E. This section is the same as Wilson's (1954a, p. 252) section 4 miles southwest of Marathon.

	THICKNESS *Feet*
Section begins on northwest limb of a large isoclinal fold.	
Marathon limestone—	
Upper part of Marathon limestone—	
Limestone, gray, fine grained, thin bedded, cross laminated with some thin coarse-grained subgraywacke lenses. COLLECTION 79, from bottom part of the section: *Dictyonema* sp., *Didymograptus extensus*, *Didymograptus nitidus*, a new genus of trilobite related to *Benthamaspis* and *Strigenalis*	10
Conglomerate, composed of flat chips and slabs of limestone	2
Covered	10
Conglomerate, composed of flat chips and slabs of thin-bedded, gray limestone and of dolomitic limestone typical of the Monument Spring member	10
Monument Spring dolomite member—	
Limestone, dolomitic, blue and yellowish, fine grained, weathers orange, in oval lenses. Shale and thin-bedded, gray, fine-grained limestone lie around and between the lenses. COLLECTION 78, from the dolomitic limestone: *Shumardoceras* sp., *Endoceras* sp.	42
Limestone, gray, fine grained, thin bedded, cross laminated, with a few interbedded lenses of conglomerate composed of flat chips and slabs of limestone. COLLECTION 76, from the upper 2 feet of this part of the section: *Clonograptus flexilis*, *Clonograptus rigidus*, *Tetragraptus approximatus*	39
Section broken at several small folds. The Marathon limestone is isoclinally folded, as revealed by similar graptolite assemblages collected in a traverse across the strike of the beds. The following part of the section was measured across the northwest limb of a large fold, 500 feet southeast from previous part of section.	
Lower part of Marathon limestone—	
Limestone, gray, fine grained, thin bedded, cross laminated	12
Conglomerate, composed of flat chips and slabs of limestone	2
Limestone, dark gray, sublithographic, weathering bluish gray. COLLECTION 75: *Adelograptus* sp., *Dendrograptus* sp.	10
Shale, black	5
Conglomerate, composed of flat chips and slabs of limestone	3
Shale, black, mostly covered	72
Limestone, gray, fine grained, thin bedded, cross laminated in layers 3 to 6 inches thick interbedded with black shale, blue-gray-weathering sublithographic limestone, and lenses of conglomerate composed of flat chips and slabs of limestone. COLLECTION 33, from 65 feet below the top of this part of the section: *Adelograptus simplex*, *Adelograptus victoriae*, *Bryograptus crassus?*, *Clonograptus flexilis*, *Clonograptus persistens*	150
Conglomerate, composed of flat chips and slabs of limestone	3
Shale, black	15
Conglomerate, composed of flat chips and slabs of limestone	1

	THICKNESS Feet
Limestone, gray, fine grained, thin bedded, cross laminated in layers 3 inches thick. COLLECTION 74: *Adelographus victoriae, Clonograptus* sp.	6
Shale, black interbedded with conglomerate composed of flat chips and slabs of limestone	35
Limestone, gray, fine grained, thin bedded, cross laminated with some interbedded black shale	14
Limestone, gray aphanitic. COLLECTION 34: *Ophileta* sp., *Pachendoceras* sp.	8
Limestone, gray, fine grained, thin bedded, cross laminated in layers 1 to 3 inches thick interbedded with black shale and lenses of conglomerate composed of flat chips and slabs of limestone	83
Subgraywacke, gray, coarse grained, calcareous, weathers brown	1
Shale, black	16
Limestone, gray, fine grained, thin bedded	2
Conglomerate, composed of flat chips and slabs of limestone	1
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with black shale and lenses of conglomerate composed of flat chips and slabs of limestone and calcareous, brown-weathering subgraywacke	136
Shale, black. COLLECTION 53: *Anisograptus* sp.	5
Shale, black, interbedded with conglomerate composed of flat chips and slabs of limestone	15
Conglomerate, composed of flat chips and slabs of limestone	5
Total lower part of Marathon limestone	600
Dagger Flat sandstone.	
Roberts Ranch member.	

SECTION II

Section on east side of gap between ridges of Marathon limestone, 9.5 miles in a straight line S. 55° W. of Marathon and 2.9 miles southwest from a cairn built on the Roberts ranch road where road turns southwest past Alsate Creek. The line of bearing of this section is S. 55° E.

	THICKNESS Feet	Inches
Fort Peña formation—		
Shale, black, interbedded with purple chert, tan-weathering gray limestone, and tan-weathering limestone pebble conglomerate. COLLECTION 95, from 5 feet above base of formation: *Dichograptus* sp., *Glyptograptus* cf. *G. austrodentatus, Isograptus caduceus* var. *maxima, Isograptus caduceus* var. *victoriae, Tetragraptus quadribrachiatus*	225	....
Alsate shale—		
Shale, black, mostly covered	85	....
Marathon limestone—		
Upper part of Marathon limestone—		
Limestone, dark gray, sublithographic, weathering bluish gray, in layers 4 to 8 inches thick. COLLECTION 66A, from 20 feet below top of formation: *Didymograptus bifidus.*	100	....
Conglomerate, composed of flat chips and slabs of limestone	3	....
Limestone, dark gray, sublithographic, weathering bluish gray	10	....
Conglomerate, composed of flat chips and slabs of limestone	5	....
Limestone, dark gray, sublithographic, weathering bluish gray, in layers 1 to 3 inches thick. COLLECTION 66, from 25 feet above the base of this part of the section: *Didymograptus extensus, Didymograptus nicholsoni, Didymograptus nitidus, Tetragraptus fruticosus* (4-branched)	105	....
Conglomerate, composed of flat limestone slabs	1	9
Limestone, dark gray, sublithographic, weathering bluish gray	5	....
Conglomerate, composed of flat limestone slabs	1	9
Limestone, dark gray, sublithographic, weathering bluish gray	5	....
Conglomerate, composed of dark gray sublithographic limestone slabs, except a few which are dolomitic limestone similar to that in the Monument Spring dolomite member	2	....
Limestone, dark gray, sublithographic, in layers 2 to 3 inches thick. COLLECTION 121: *Didymograptus nitidus, Tetragraptus fruticosus* (4-branched), *Tetragraptus quadribrachiatus, Ptilograptus plumosus, Dictyonema* sp.	12	....
Monument Spring dolomite member—		
Limestone, dolomitic, blue and yellowish, fine grained, orange weathering, in oval lenses. Shale and thin-bedded gray fine-grained limestone lie around and be-		

tween the lenses. COLLECTION 120, from black shale interbedded with the dolomitic limestone, *Clonograptus flexilis, Didymograptus extensus, Tetragraptus approximatus, Tetragraptus bigsbyi, Tetragraptus quadribrachiatus, Tetragraptus taraxacum*	51	6
Lower part of Marathon limestone—		
Shale, black	69	....
Conglomerate, composed of flat chips and slabs of limestone with a brown quartz sand matrix. Along strike the conglomerate passes into coarse-grained, brown subgraywacke	18	3
Shale, black	19	....
Conglomerate, composed of flat chips and slabs of limestone	5	....
Shale, black, interbedded with thin beds of dark gray, sublithographic limestone which weathers bluish gray and thin-bedded, gray, fine-grained limestone	44	3
Subgraywacke, gray, coarse-grained, calcareous, weathers brown	....	9
Conglomerate, composed of flat limestone slabs	2	6
Shale, black	19	9
Conglomerate, composed of flat chips and slabs of limestone	1	....
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with black shale and dark gray, sublithographic limestone which weathers bluish gray	162	....
Limestone, light gray, fine grained, oolitic. COLLECTION 118: *Bellefontia* sp., *Lloydia* sp.	....	10
Shale, greenish black, interbedded with coarse-grained gray calcareous subgraywacke and conglomerate composed of quartz pebbles in a brown quartz sand matrix	49	....
Limestone, gray, fine grained, thin bedded	9	....
Shale, black, interbedded with coarse-grained gray calcareous subgraywacke	22	9
Conglomerate, composed of flat chips and slabs of limestone	1	....
Subgraywacke, gray, coarse grained, calcareous, weathers brown	1	....
Shale, greenish black	7	5
Subgraywacke, gray, coarse grained, calcareous, weathers brown	....	3
Shale, greenish black	37	3
Shale, black, interbedded with gray fine grained limestone and gray chert. COLLECTION 119: *Anisograptus* sp., *Clonograptus* cf. *C. tenellus*	2	....
Shale, greenish black, interbedded with a few thin beds of coarse-grained gray calcareous subgraywacke and gray fine-grained limestone	70	....
Total Marathon limestone	844	....
Dagger Flat sandstone—		
Roberts Ranch member—		
Subgraywacke, gray, coarse grained, calcareous, weathers brown	2	....
Shale, greenish black	42	....
Total Dagger Flat sandstone exposed	44	....

SECTION III

Section on southeast limb of Marathon anticlinorium at a cairn built on Roberts ranch road where the road turns southwest past Alsate Creek. The cairn is 6.6 miles S. 55° W. of Marathon and 2.7 miles S. 85° W. of the Picnic Grounds 5 miles south-southwest of Marathon. The line of bearing of the section is S. 55° E.

	THICKNESS	
	Feet	*Inches*
Alsate shale—		
Shale, black, breaks into rhomboid chips	46	....
Marathon limestone—		
Upper part of Marathon limestone—		
Conglomerate, composed of flat chips and slabs of limestone	5	....
Limestone, gray, fine grained, thin bedded, cross laminated, in layers 4 to 6 inches thick interbedded with dark gray, sublithographic limestone which weathers bluish gray in layers 2 to 3 inches thick	25	....
Limestone, dark gray, sublithographic, weathers bluish gray. COLLECTION 30: *Didymograptus protobifidus, Phyllograptus ilicifolius, Phyllograptus angustifolius, Tetragraptus quadribrachiatus*	....	6
Limestone, dark gray, sublithographic, weathers bluish gray in layers 6 to 8 inches thick interbedded with thin-bedded, cross-bedded, gray, fine-grained limestone in layers 4 to 6 inches thick. COLLECTION 5, from 12 feet above base of this part of the section: *Dictyonema* sp., *Didymograptus* sp.	118	....
Conglomerate, composed of flat limestone slabs which are elongate subparallel to the bedding	1	....

	THICKNESS Feet	Inches
Limestone, dark gray, sublithographic, weathers bluish gray, in layers 4 to 6 inches thick interbedded with thin-bedded, fine-grained, gray limestone in layers 3 to 6 inches thick	17	....
Subgraywacke, coarse grained, weathers brown	....	6
Limestone, dark gray, sublithographic, weathers bluish gray in layers 4 to 6 inches thick, interbedded with thin-bedded, cross-bedded, gray, fine-grained limestone in layers 6 to 8 inches thick. COLLECTION 4, from 20 feet above the base of this part of the section: *Didymograptus extensus, Tetragraptus fruticosus* (4-branched)	85	....
Monument Spring dolomite member—		
Limestone, dolomitic, blue and yellowish, fine grained, weathers orange, in oval lenses. Shale and thin-bedded, gray, fine-grained limestone lies around and between the lenses. COLLECTION 31: *Archeoscyphia* sp., fragments of orthoid brachiopods, cephalopods, and gastropods	65	....
Total upper part of Marathon limestone and Monument Spring dolomite member	317	....
Break section because of complex folding.		
Lower part of Marathon limestone—		
Shale, buff, calcareous	18	....
Conglomerate, composed of flat limestone slabs which are subparallel to the bedding	1	....
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray, sublithographic limestone which weathers bluish gray. COLLECTION 3: Acrotretid brachiopods	18	9
Conglomerate, composed of flat chips and slabs of limestone	1	....
Limestone, dark gray, sublithographic, weathers bluish gray, in layers 4 to 6 inches thick interbedded with thin-bedded, cross-laminated, gray, fine-grained limestone in layers 6 to 8 inches thick. COLLECTION 2: *Clonograptus flexilis, Clonograptus* sp.	42	....
Conglomerate, composed of flat limestone slabs which are subparallel to the bedding	16	5
Shale, buff, calcareous	28	3
Conglomerate, composed of flat limestone slabs which are up to 2 feet in length and are elongate subparallel to the bedding	5	....
Shale, black, weathers greenish, interbedded with buff, calcareous shale	23	4
Shale, buff, calcareous	46	9
Conglomerate, composed of flat limestone slabs	1	6
Limestone, gray, fine grained, thin bedded. COLLECTION 1: *Lingula* sp.	4	6
Conglomerate, composed of flat limestone slabs which are elongate subparallel to the bedding	10	....
Sandstone, quartzose, coarse grained, weathers brown	....	4
Shale, buff, calcareous	5	4
Conglomerate, composed of flat limestone slabs which are elongate subparallel to the bedding	16	6
Limestone, gray, fine grained, thin bedded	4	....
Conglomerate, composed of flat limestone slabs which are elongate subparallel to the bedding	4	....
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray sublithographic limestone which weathers bluish gray	57	....
Conglomerate, composed of flat limestone slabs	2	6
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray, sublithographic limestone which weathers bluish gray	21	4
Conglomerate, composed of flat limestone slabs	2	....
Total lower part of Marathon limestone exposed	329	6

SECTION IV

Section in creek bed on south side of U. S. Highway 90, 1 mile west of railroad station in Marathon. The section was measured in northwest direction.

	THICKNESS Feet	Inches
Marathon limestone—		
Covered.		
Limestone, dark gray, sublithographic, weathering bluish gray, in layers 1 to 6 inches thick	55	....
Covered	49	....

Limestone, gray, fine grained, thin bedded, interbedded with black shale. COLLECTION 12: *Clonograptus persistens, Clonograptus* sp.	62	6
Shale, buff, calcareous, COLLECTION 11: *Adelograptus hunnebergensis?, Clonograptus rigidus, Clonograptus flexilis*	17	6
Conglomerate, composed of flat chips and slabs of limestone	1	....
Limestone, gray, fine grained, in layers 2 to 3 inches thick interbedded with buff calcareous shale. COLLECTION 29: *Anisograptus* sp., *Triograptus* cf. *T. otagoensis, Dictyonema* sp.	45	....
End section in covered area.		
Total Marathon limestone exposed	230	....

SECTION V

Section 9.4 miles S. 56° W. of Marathon along a line trending S. 60° E. across the Roberts ranch road at a point 2¾ miles southwest from a cairn built where the road turns southwest past Alsate Creek.

	THICKNESS Feet
Begin section on limb of fold.	
Marathon limestone—	
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray, sublithographic limestone which weathers bluish gray and conglomerate composed of flat chips and slabs of limestone. COLLECTION 67, from 24 feet below the top of this part of the section: *Didymograptus bifidus, Didymograptus similis, Phyllograptus anna, Phyllograptus typus*	103
Limestone, dark gray, sublithographic, weathering bluish gray, in layers 1 to 4 inches thick, interbedded with thin-bedded, gray, fine-grained limestone and a few lenses of conglomerate composed of flat chips of limestone. COLLECTION 68, from 10 feet below the top of this part of the section: *Didymograptus nicholsoni, Didymograptus nitidus, Didymograptus patulus*	44
Conglomerate, composed of flat chips and slabs of limestone which are elongate parallel to the bedding	3
Limestone, black, fine grained, weathering orange, interbedded with lenses of conglomerate composed of flat chips and slabs of limestone	10
Limestone, dark gray, sublithographic, weathering bluish gray	10
Limestone, black, fine grained, weathering orange, interbedded with lenses of limestone pebble conglomerate. The pebbles are 1/16 inch in diameter and are scattered in a brown, coarse-grained, quartz sand matrix	12
Shale, black, weathers buff, with some interbedded, thin-bedded, cross-bedded, gray, fine-grained limestone. COLLECTION 69, from basal 5 feet of this part of the section: *Clonograptus flexilis, Dichograptus octobrachiatus, Didymograptus nicholsoni* var. *planus, Didymograptus nitidus, Didymograptus* cf. *D. patulus, Didymograptus* sp., *Tetragraptus amii, Tetragraptus fruticosus* (4-branched), *Tetragraptus quadribrachiatus*	49
Conglomerate, composed of flat chips and slabs of limestone	5
Section ended on limb of fold.	
Total Marathon limestone measured	236

SECTION VI

Section 6.9 miles S. 53° W. of Marathon on the southeast limb of the Marathon anticlinorium along line bearing S. 55° E. The section is on the southeast side of the Roberts ranch road, 0.4 mile southwest of a cairn built where the road turns southwest past Alsate Creek.

	THICKNESS Feet	Inches
Marathon limestone.		
Monument Spring dolomite member—		
Limestone, dolomitic, blue and yellowish, fine grained, weathers orange, in oval lenses. Shale and thin-bedded, gray, fine-grained limestone lie around and between the lenses. COLLECTION 130: *Clonograptus* sp., *Tetragraptus approximatus*	51	9
Lower part of Marathon limestone—		
Limestone, gray, fine grained, thin bedded, cross laminated, in layers 3 to 6 inches thick interbedded with black shale, buff-weathering, black, fine-grained limestone with orange-weathering chert stringers, dark gray, sublithographic limestone which weathers bluish gray in layers 1 to 2 inches thick, and lenses of conglomerate composed of flat slabs of limestone up to 50 feet long and 6 feet thick	132	....

Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with black shale and lenses of coarse-grained, calcareous subgraywacke which weathers brown. COLLECTION 84, from basal 2 feet of this part of the section: *Callograptus* sp., *Clonograptus rigidus, Clonograptus tenellus* var. *callavei, Dictyonema* sp., *Didymograptus* sp., *Tetragraptus decipiens, Triograptus* cf. *T. otagoensis*	31	....
Limestone, gray, fine grained, thin bedded, cross laminated, in layers 1 to 4 inches thick; black shale; dark gray, sublithographic limestone which weathers bluish gray, in layers 1 to 1½ inches thick; lenses of conglomerate composed of flat limestone slabs; and lenses of coarse-grained, calcareous subgraywacke which weathers brown	75	....
Conglomerate, composed of flat limestone slabs	6	....
End section in covered area.	—	—
Total Marathon limestone exposed	295	9

SECTION VII

Section along a line trending S. 55° E. on the southeast limb of the Dagger Flat anticlinorium at a locality 2½ miles east-northeast of Buttrill ranch. Part of this section was described originally by Wilson (1954a, pp. 251–252).

	THICKNESS *Feet*	*Inches*
Alsate shale—		
Shale, black. Base of formation exposed	5	....
Marathon limestone—		
Upper part of Marathon limestone—		
Limestone, gray, fine grained, thin bedded, cross laminated, with some interbedded black shale which is well indurated. COLLECTION 40, from base of this part of the section: *Didymograptus extensus, Didymograptus protobifidus, Goniograptus* sp. *Phyllograptus angustifolius, Phyllograptus ilicifolius, Tetragraptus amii, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus pygmaeus, Tetragraptus quadribrachiatus*	33	....
Fault		
Lower part of Marathon limestone—		
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with thin-bedded, gray, fine-grained limestone. COLLECTION 43, from 10 feet below the top of this part of the section: *Adelograptus victoriae, Clonograptus* sp.	35	6
Conglomerate, composed of flat limestone slabs	1	6
Shale, calcareous, weathers buff	11	....
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray, sublithographic limestone which weathers bluish gray, black shale, lenses of conglomerate composed of flat limestone slabs, and layers of coarse-grained subgraywacke which weathers brown	127	....
Subgraywacke, coarse grained, calcareous, weathers brown	3	....
Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with dark gray, sublithographic limestone which weathers bluish gray. COLLECTION 37: *Adelograptus simplex, Bryograptus crassus* ?, *Clonograptus* sp.	4	6
Shale, black	7	....
Conglomerate, composed of flat limestone slabs	3	....
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with black shale	12	4
Conglomerate, composed of flat limestone slabs	2	....
Limestone, gray, fine grained, thin bedded, cross laminated	9	....
Conglomerate, composed of flat limestone slabs	1	6
Limestone, dark gray, sublithographic, weathering bluish gray	13	....
Conglomerate, composed of limestone pebbles which are ¼ to ½ inch in diameter and are rounded	1	2
Covered	17	6
Limestone, gray, fine grained, thin bedded, cross laminated	1	....
Covered	4	....
Subgraywacke, coarse grained, calcareous, weathering brown	1	9
Conglomerate, composed of flat chips and slabs of limestone	2	3
Shale, black	5	....
Limestone, gray, fine grained, thin bedded, cross laminated	4	....
Shale, black	16	....
Conglomerate, composed of flat chips and slabs of limestone	2	....

Limestone, gray, fine grained, thin bedded, cross laminated, interbedded with black shale and lenses of coarse grained, calcareous subgraywacke which weathers brown	33	....
Conglomerate, composed of flat chips and slabs of limestone	2	....
Total lower part of Marathon limestone present	320	....
Dagger Flat sandstone.		
Roberts Ranch member.		

SECTION VIII

Section 7.4 miles S. 54° W. of Marathon along a line trending S. 55° E. On southeast limb of Marathon anticlinorium, on southeast side of Roberts ranch road, 0.8 mile south of a cairn built where the road turns southwest past Alsate Creek.

	THICKNESS *Feet*	*Inches*
Marathon limestone—		
Limestone, dark gray, sublithographic, weathering bluish gray in layers 3 to 6 inches thick with some interbedded thin-bedded, gray, fine-grained limestone. COLLECTION 72C: *Clonograptus* sp., *Didymograptus novus*	66	....
Conglomerate, composed of flat limestone slabs which are elongate subparallel to the bedding	1	....
Shale, buff, calcareous. COLLECTION 72B: *Anisograptus* sp., *Clonograptus* cf. *C. tenellus, Dictyonoma* sp.	19	9
Conglomerate, composed of flat chips and slabs of limestone	3	....
Covered	16	....
Sandstone, quartzose, coarse grained, calcareous, weathers brown	1	6
Shale, black	5	....
Limestone, gray, fine grained, thin bedded	4	4
Subgraywacke, gray, coarse grained, calcareous	1	8
Shale, buff, calcareous, interbedded with black shale, thin-bedded, gray, fine-grained limestone and gray, coarse-grained, calcareous subgraywacke	58	....
Shale, buff, calcareous. COLLECTION 72A: *Anisograptus* sp.	10	....
Conglomerate, composed of flat chips and slabs of limestone	5	9
Shale, black, highly contorted.		
Total Marathon limestone exposed	192	....

SECTION IX

Section 7.2 miles S. 53° W. of Marathon along a line trending S. 55° E. Begins on southeast limb of the Marathon anticlinorium, one-fourth mile southeast of the Roberts ranch road at a point three-fourths of a mile southwest from a cairn built where the road turns southwest past Alsate Creek.

	THICKNESS *Feet*	*Inches*
Marathon limestone—		
Monument Spring dolomite member—		
Limestone, dolomitic, blue and yellowish, fine grained, weathers orange, in oval lenses. Shale and thin-bedded, gray, fine-grained limestone lie around and between the lenses	55	....
Shale, black. COLLECTION 80: *Clonograptus* sp., *Dichograptus octobrachiatus, Tetragraptus approximatus*	2	
Lower part of Marathon limestone—		
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with thin-bedded, cross-laminated, gray, fine-grained limestone, black shale, and lenses of conglomerate composed of flat chips and slabs of limestone	175	
Conglomerate, composed of flat chips and slabs of limestone	3	9
Shale, black, interbedded with buff-weathering calcareous shale. COLLECTION 72E: *Adelograptus simplex, Adelograptus victoriae, Anisograptus* sp., *Dictyonema* sp., *Didymograptus novus, Tetragraptus decipiens*	24	2
Limestone, gray, fine grained, thin bedded, cross laminated, in layers 3 to 8 inches thick	21	
Conglomerate, composed of flat chips and slabs of limestone	3	4
Shale, calcareous, weathers buff. COLLECTION 59: *Adelograptus hunnebergensis?, Clonograptus* sp.	8	9
Total Marathon limestone measured	293	....

SECTION X

Section along a line bearing S. 55° E. across a ridge of the Fort Peña formation at a point 6.5 miles S. 51° W. of Marathon and 2½ miles west-southwest of the Picnic Grounds (5 miles south-southwest of Marathon) on the southeast side of the Roberts ranch road. The section was measured on the ridge southeast of a cairn built where the road turns southwest past Alsate Creek.

	THICKNESS *Feet*
Woods Hollow shale, not well exposed.	
Fort Peña formation—	
Limestone, gray, medium grained, thin bedded, weathering brown	30
Limestone, gray, medium grained, thin bedded, weathering brown in layers 6 inches to 1 foot thick, interbedded with purple chert. COLLECTION 117A, from 15 feet above the base of this part of the section: *Glyptograptus* cf. *G. austrodentatus*	75
Conglomerate, composed of chert and limestone pebbles. The pebbles are 1/16 to 1/4 inch in diameter and are set in a gray limestone matrix	1
Limestone, gray, medium grained, thin bedded, weathering brown, in layers 4 inches to 1 foot thick, black shale in layers 6 inches to 2 feet thick, and conglomerate, composed of chert and limestone pebbles, in layers 4 to 8 inches thick. COLLECTION 117, from 65 feet above the base of this part of the section: *Glyptograptus* cf. *G. austrodentatus, Hallograptus etheridgei*	84
Limestone, gray, medium grained, thin bedded, arenaceous, grading downward to conglomerate. The limestone contains some conglomerate seams	15
Conglomerate, weathering brown. The pebbles are of quartz, chert, and limestone and are set in a matrix of gray limestone. The conglomerate intergrades along strike with gray, medium-grained, arenaceous limestone which weathers brown	16
Total Fort Peña formation	221
Alsate shale—	
Shale, black	112
Marathon limestone—	
Limestone, dark gray, sublithographic, weathering bluish gray	5
Chert, black	1
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with thin-bedded, gray, fine-grained limestone	55
End section on fold crest.	
Total Marathon limestone measured	61

SECTION XI

Section 5.6 miles southeast of Marathon on northwest face of ridge which forms the southeast side of the anticlinal valley in which the old Louis Granger place was located.

	THICKNESS *Feet*	*Inches*
Maravillas chert.		
Woods Hollow shale—		
Shale, black, weathering greenish, interbedded with gray siltstone which weathers tan	45	....
Shale, black, weathering greenish	33	6
Limestone, gray, fine grained, thin bedded. COLLECTION 103: *Climacograptus bicornis, Climacograptus eximius, Corynoides tricornis, Cryptograptus tricornis, Dicellograptus sextans*	....	6
Shale, black, weathering greenish	39	6
Shale, black, weathering greenish, interbedded with gray siltstone which weathers tan in layers ½ inch to 1½ inches thick and thin-bedded, gray, fine-grained limestone in layers ¼ inch thick	112	....
Limestone, gray, coarse grained, weathering brown with silicified fragments of bryozoa, trilobites, and crinoid columnals on the surface	....	4
Shale, black, weathering greenish	12	....
Shale, black, weathering greenish, interbedded with gray siltstone which weathers tan in layers ½ to 1 inch thick and thin-bedded, gray, fine-grained limestone in layers ¼ inch thick	96	9
Limestone, gray, fine grained, thin bedded, weathers brown and has silicified fragments of bryozoa, brachiopods, and crinoid columnals on the surface	....	3
Shale, black, weathering greenish	19	6
Limestone, gray, fine grained, thin bedded. COLLECTION 148: *Dicellograptus sextans, Dicellograptus intortus, Glyptograptus teretiusculus* var. *euglyphus, Nemagraptus exilis* var. *linearis*	....	4

Shale, black, weathering greenish, interbedded with thin-bedded, fine-grained, gray limestone in layers ¼ inch thick and gray siltstone which weathers tan in layers ½ to 1 inch thick	43	....
Conglomerate, composed of flattened pebbles of black shale in a gray, silty limestone matrix	.....	6
Shale, black, weathering greenish	8	....
Siltstone, gray, thin bedded, weathers tan, in layers 2 to 6 inches thick interbedded with thin-bedded, gray, fine-grained limestone in layers 1 to 4 inches thick. COLLECTION 46A, from 2 feet below the top of this part of the section: *Amplexograptus confertus, Climacograptus riddellensis, Glyptograptus* cf. *G. teretiusculus*	24	10
Total Woods Hollow shale	436	....
Fort Peña formation—		
Limestone, gray, fine grained, thin bedded, in layers 1 inch to 1½ feet thick with some interbedded black shale and gray, fine-grained siltstone. COLLECTION 92: *Amplexograptus confertus, Glyptograptus* cf. *G. teretiusculus*	35	....

The rocks of the Fort Peña formation form a low anticlinal ridge in the middle of the valley.

SECTION XII

Section on northwest face of ridge which trends northeast from the Picnic Grounds (5 miles south-southwest of Marathon) at a point ⅜ mile northeast of the grounds and 4.1 miles in a straight line S. 33° W. of Marathon.

	THICKNESS Feet	Inches
Maravillas chert—		
Covered.		
Chert, black, in layers 3 to 6 inches thick interbedded with fine-grained black limestone which weathers gray in layers 8 to 18 inches thick. Chert stringers up to 1 inch thick occur in the limestones. COLLECTION 99, from 13 feet above the base of the formation: *Orthograptus* sp., *Ampyxina* sp.	50	....
Woods Hollow shale—		
Shale, greenish black	12	....
Shale, black, interbedded with thin-bedded, gray limestone in layers ⅛ inch thick. COLLECTION 105: *Corynoides incurvus. Cryptograptus tricornis. Dicellograptus sextans, Didymograptus serratulus, Orthograptus whitfieldi, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *pygmaeus*	2	6
Shale, black, interbedded with thin-bedded, gray siltstone which weathers brown and thin-bedded, gray limestone in ⅛-inch layers. COLLECTION 100: *Dicellograptus sextans, Didymograptus serratulus, Glyptograptus teretiusculus* var. *euglyphus, Orthograptus calcaratus* var. *alabamensis, Cryptograptus tricornis*	5	3
Shale, black, with a few interbedded thin siltstone layers which weather brown	88	3
Siltstone, gray, weathering orange brown	.....	6
Shale, black, bears mud cracks	7	3
Conglomerate, composed of flattened pebbles of black shale in a matrix of gray siltstone	1	3
Shale, black, bears mud cracks	2	....
Conglomerate, composed of flattened pebbles of black shale in a matrix of gray siltstone	1	6
Shale, black, with a few interbedded thin layers of gray siltstone which weathers brown	24	....
End section on fold.		
Total Woods Hollow shale measured	144	6

SECTION XIII

Section 2½ miles in a direct line southwest of the Picnic Grounds on the northeastern bend in the ridge north of Sunshine Springs.

	THICKNESS Feet	Inches
Maravillas chert.		
Woods Hollow shale—		
Siltstone, gray, weathering tan, interbedded with black shale which weathers greenish	32	....
Shale, black, weathering greenish	39	....
Shale, black, weathering greenish, interbedded with gray siltstone which weathers tan and thin-bedded, gray, fine-grained limestone	45	....
Shale, black, weathering greenish	23	6

Shale, black, weathering greenish, interbedded with thin layers of gray siltstone which weathers tan and thin-bedded, gray, fine-grained limestone. COLLECTION 124: *Climacograptus* sp., *Corynoides* sp., *Glyptograptus* sp.	8	....
Shale, black, weathering greenish	7	....
Shale, black, weathering greenish, interbedded with thin layers of gray siltstone which weathers tan. COLLECTION 123: *Aparchites* sp., *Eurychilina papillata*	14	....
Shale, black, weathering greenish, interbedded with thin layers of gray siltstone which weathers gray and thin-bedded, gray, fine-grained limestone. COLLECTION 122, from bottom of this part of the section: *Climacograptus scharenbergi* cf. var. *stenostoma, Corynoides calicularis, Cryptograptus tricornis, Dicellograptus divaricatus, Dicellograptus gurleyi, Dicellograptus intortus, Dicellograptus sextans, Dicellograptus smithi, Dicranograptus brevicaulis, Nemagraptus gracilis, Retiograptus geinitzianus*	19	6
Shale, black, weathering greenish	19	6
Siltstone, gray, weathers tan	1	6
End of section at several small folds.		
Total Woods Hollow shale measured	209	....

SECTION XIV

Section on northwest face of cliff at Rock House Gap near the southwestern end of the southeast limb of the Marathon anticlinorium. Rock House Gap is 13.4 miles in a direct line S. 46° W. of Marathon.

	THICKNESS Feet	Inches
Maravillas chert—		
Shale, pink, interbedded with pink chert	5	....
Chert, black, in layers 8 inches to 2 feet thick interbedded with black, petroliferous, fine-grained limestone which weathers gray in layers 8 inches to 1 foot thick	121	....
Chert, black	2	6
Limestone, black, fine grained, petroliferous, weathering gray. COLLECTION 73A: *Orthograptus quadrimucronatus*	....	6
Conglomerate, composed of chert and limestone pebbles	1	....
Chert, black, with a few interbedded lenses of black, fine-grained limestone which weathers gray and of chert pebble conglomerate	39	....
Limestone, black, fine grained, weathering gray in layers 8 inches to 2½ feet thick with some interbedded black chert	12	10
Conglomerate, composed of chert pebbles in a black limestone matrix. COLLECTION 73: *Climacograptus antiquus, Climacograptus scharenbergi, Climacograptus typicalis, Dicranograptus nicholsoni* var. *geniculatus, Orthograptus quadrimucronatus* var. *angustus, Orthograptus truncatus* var. *intermedius, Retiograptus pulcherrimus*	....	6
Limestone, black, fine grained, weathering gray in layers 2 to 6 inches thick interbedded with black chert in layers ½ inch to 2 inches thick and lenses of conglomerate composed of chert pebbles	10	3
Conglomerate, composed of chips of black chert, limestone, quartzose sandstone, and dolomite in a coarse-grained quartz sand matrix. COLLECTION 146, from 5 feet above base of the formation: *Streptelasma* sp.	10	....
Total Maravillas chert exposed	202	7

SECTION XV

Section on cliff rising above Picnic Grounds 4.5 miles in a direct line S. 34° W. of Marathon.

	THICKNESS Feet	Inches
Maravillas chert—		
Shale, pink, interbedded with pink and brown chert in layers ½ inch to 3 inches thick. COLLECTION 60: *Dicellograptus complanatus, Dicellograptus complanatus* var. *arkansasensis, Dicellograptus complanatus* var. *ornatus, Diplograptus crassitestus, Climacograptus hastatus, Climacograptus mississippiensis, Climacograptus putillus, Orthograptus truncatus* var. *socialis, Retiograptus deckeri*	4	9
Chert, black	....	6
Shale, buff, weathering pink	1	....
Chert, black, in layers 3 inches to 2 feet thick	20	....
Chert, black, in layers 6 inches to 1½ feet thick interbedded with black, fine-grained limestone which weathers gray in layers 2 to 7 inches thick and a few lenses of black shale ¼ inch thick. COLLECTION 86A, from 2 feet above the base of this part of the section: *Climacograptus minimus, Climacograptus tubuliferus, Orthograptus quadrimucronatus?*	34	....

Conglomerate, composed of chert and limestone pebbles up to ⅛ inch in diameter	1	....
Chert, black, in layers 6 inches to 1½ feet thick, interbedded with black, fine-grained limestone which weathers gray in layers 4 inches to 1 foot thick and a few lenses of conglomerate composed of chert and limestone pebbles with fragments of bryozoa in matrix	127	....
Shale, black	....	6
Limestone, black, fine grained, weathering gray, and has chert stringers	3	....
Conglomerate, composed of chert and limestone pebbles	1	....
Chert, black	2	....
Limestone, black, fine grained, weathering gray. COLLECTION 86B: *Climacograptus spiniferus, Climacograptus* sp., *Orthograptus quadrimucronatus* var. *angustus, Orthograptus truncatus* var. *intermedius, Orthograptus* aff. *O. truncatus, Retiograptus pulcherrimus*	2	6
Chert, black	4	....
Limestone, black, fine grained, weathering gray	3	6
Conglomerate, composed of chert and limestone pebbles	1	....
Limestone, black, fine grained, weathering gray. COLLECTION 134: *Dicellograptus forchammeri* var. *flexuosus, Dicranograptus nicholsoni, Orthograptus* cf. *O. truncatus* var. *intermedius, Orthograptus* aff. *O. truncatus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Retiograptus pulcherrimus, Climacograptus antiquus, Climacograptus scharenbergi, Climacograptus spiniferus*	4	....
Chert, black	1	6
Conglomerate, composed of chert and limestone pebbles up to ⅛ inch in diameter	1	4
Limestone, black, fine grained, weathering gray. COLLECTION 134A: *Dicellograptus forchammeri* var. *flexuosus, Dicranograptus nicholsoni, Dicranograptus nicholsoni* var. *geniculatus, Orthograptus truncatus* var. *intermedius, Orthograptus quadrimucronatus* var. *angustus, Orthograptus quadrimucronatus* var. *cornutus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Climacograptus scharenbergi, Climacograptus antiquus, Retiograptus pulcherrimus, Orthograptus truncatus* var. *pertenuis*	3	2
Chert, black, interbedded with black, fine-grained limestone which weathers gray and has chert stringers	10	....
Limestone, black, fine grained, weathering gray. COLLECTION 133: *Climacograptus typicalis, Climacograptus typicalis* var. *crassimarginalis, Climacograptus* sp.	3	....
Chert, black	2	....
Conglomerate, composed of chert and limestone pebbles	1	....
Limestone, black, fine grained, weathering gray	3	....
Chert, black	3	....
Limestone, black, fine grained, weathering gray. COLLECTION 135, from basal 6 inches of the formation: *Climacograptus antiquus, Climacograptus typicalis* var. *crassimarginalis, Ampyxina* sp., *Cryptolithus* sp.	1	....
Total Maravillas chert	238	9

Woods Hollow shale at base of section, exposed in creek.

SECTION XVI

Section 2 miles N. 55° E. of Woods Hollow Tank on southeast face of ridge which forms the northwest limb of the Dagger Flat anticlinorium.

	THICKNESS Feet	Inches
Maravillas chert—		
Chert, black	17	6
Limestone, black, fine grained, weathering gray	....	6
Chert, black	20	....
Limestone, black, fine grained, weathering gray	1	....
Chert, black	14	....
Conglomerate, composed of chert and limestone pebbles	1	....
Chert, black	6	3
Limestone, black, fine grained, weathering gray and has chert stringers	1	9
Chert, black	1	8
Limestone, black, fine grained, weathering gray and has chert stringers	1	9
Chert, black	4	5
Limestone, black, fine grained, weathering gray	1	6
Chert, black	5	4
Limestone, black, fine grained, weathering gray. COLLECTION 45: *Climacograptus* sp., *Climacograptus tubuliferus, Diplograptus minutus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Orthograptus quadrimucronatus, Orthograptus truncatus* var. *recurrens, Retiograptus pulcherrimus*	1	4

Chert, black	5	4
Limestone, black, fine grained, weathering gray	....	10
Chert, black	9	9
Limestone, black, fine grained, weathering gray	....	4
Chert, black	4	....
Limestone, black, fine grained, weathering gray	1	9
Chert, black	8	10
Limestone, black, fine grained, weathering gray	.....	4
Chert, black	19	....
Limestone, black, fine grained, weathering gray	1	9
Chert, black	7	10
Subgraywacke, brown, coarse grained	.....	2
Chert, black	1	6
Subgraywacke, brown, coarse grained	.....	2
Chert, black, in layers 2 to 8 feet thick interbedded with black, fine-grained limestone which weathers gray in layers 5 inches to 2½ feet thick	124	....
Conglomerate, composed of black chert pebbles	.....	9
Chert, black, in layers 6 inches to 3 feet thick interbedded with black, fine-grained limestone which weathers gray in layers 6 inches to 1 foot thick	14	5
Conglomerate, composed of black chert pebbles	.....	9
Chert, black, in layers 6 inches to 3 feet thick interbedded with black, fine-grained limestone which weathers gray in layers 4 inches to 1 foot thick	71	....
Conglomerate, composed of black chert pebbles	.....	10
Chert, black	6	9
Total Maravillas chert	358	1

Woods Hollow shale.

SECTION XVII

Section on north slope of Threemile Hill.

	THICKNESS *Feet*	*Inches*
Maravillas chert—		
Chert, black in layers 1 to 3 feet thick	29	10
Limestone, black, fine grained, weathering gray and has chert stringers	2	6
Chert, black, in layers 1 to 3 feet thick interbedded with a few thin layers of black, fine-grained limestone which weathers gray	80	....
Limestone, black, fine grained, weathering gray	5	6
Chert, black, in layers 1 to 3 feet thick interbedded with black, fine-grained limestone which weathers gray in layers 1 to 6 inches thick	64	6
Limestone, black, fine grained, weathering gray	10	....
Limestone, light gray, coarse grained, crowded with bryozoan fragments	4	....
Limestone, black, fine grained, weathering gray	4	6
Limestone, light gray, coarse grained, crowded with fragments of bryozoa and trilobites, COLLECTION 51: *Cryptolithus* sp., *Flexicalymene* sp., *Hallopora* sp.	4	....
Limestone, black, fine grained, weathering gray	18	6
Chert, black	1	10
Limestone, black, fine grained, weathering gray	11	3
Limestone, black, fine grained, weathering gray, in layers 6 inches to 1 foot thick; some interbedded black chert in layers 6 inches to 1 foot thick	67	....
Conglomerate, composed of chert and limestone pebbles with bryozoan fragments in the matrix	6	6
Limestone, black, fine grained, weathering gray	9	....
Chert, black, in layers 6 inches to 2 feet thick interbedded with black, fine grained limestone which weathers gray in layers 6 inches to 1 foot thick	62	6
Chert, black	3	....
Total Maravillas chert exposed	384	5

Fault

Marathon limestone.

SECTION XVIII

Section in bed of Alsate Creek 3 miles west of the Picnic Grounds (5 miles south-southwest of Marathon) and 6.1 miles S. 54° W. of Marathon. Measured on a line bearing S. 55° W.

	THICKNESS *Feet*	*Inches*
Fort Peña formation—		
Shale, black	....	8
Chert, purple	....	2

Shale, black	....	7
Limestone, gray, arenaceous. COLLECTION 13: *Callograptus* sp., *Cryptograptus schaferi, Glossograptus acanthus, Glossograptus hincksii, Glyptograptus intersitus, Isograptus ovatus, Hallograptus echinatus, Hallograptus etheridgei, Loganograptus logani, Tetragraptus quadribrachiatus, Trigonograptus ensiformis, Retiograptus speciosus?*	....	2
Shale, black	1	....
Chert, purple	....	2
Shale, black	2	....
Chert, purple	....	6
Limestone, gray, medium grained, thin bedded	....	6
Shale, black	....	5
Chert, purple	....	3
Shale, black interbedded with purple chert. Graptolites were found in all the shale beds. COLLECTION 14: *Callograptus* sp., *Cryptograptus schaferi, Dichograptus marathonensis, Didymograptus cuspidatus, Glossograptus acanthus, Glyptograptus* sp., *Hallograptus etheridgei, Tetragraptus quadribrachiatus*	7	....
Shale, black, interbedded with purple chert and thin-bedded, medium-grained, gray limestone. Graptolites were found in the base of this part of the section. The bed in which they were found is marked with yellow paint. COLLECTION 15: *Callograptus* sp., *Cryptograptus schaferi, Didymograptus* sp., *Glossograptus hystrix, Glyptograptus* cf. *G. austrodentatus, Glyptograptus intersitus, Isograptus caduceus* var. *divergens, Isograptus forcipiformis* var. *latus, Hallograptus etheridgei, Tetragraptus quadribrachiatus, Trigonograptus ensiformis*	12	10
Limestone, gray, medium grained, thin bedded, interbedded with black shale. COLLECTION 16: *Didymograptus cuspidatus, Didymograptus nodosus, Glossograptus* sp., *Glyptograptus intersitus, Isograptus forcipiformis* var. *latus, Pterograptus incertus*	4	2
Chert, purple	....	5
Limestone, gray, medium grained, thin bedded	....	8
Chert, purple	....	6
Fault		
Shale, black, interbedded with thin-bedded, medium-grained, gray limestone	3	5
Shale, black. COLLECTION 17: *Isograptus caduceus* var.?	....	2
Shale, black, interbedded with thin-bedded, gray, fine-grained limestone	17	9
Section crosses a small fold, and measurements continue on northwest limb of fold.		
Chert, purple, interbedded with thin-bedded, medium-grained, gray limestone, black shale, and subgraywacke in layers 1 to 3 inches thick. COLLECTION 149, from 40 feet above base of this part of the section: *Glossograptus acanthus, Glossograptus hincksii, Glyptograptus* sp., *Hallograptus echinatus, Hallograptus etheridgei*	73	....
Limestone, gray, medium grained, thin bedded, interbedded with conglomerate composed of chert and limestone pebbles. The pebbles in the conglomerate are a maximum of 1/16 inch in diameter	10	....
Conglomerate, composed of flat chips and slabs of limestone	2	....
Limestone, gray, medium grained, thin bedded	5	....
Conglomerate, composed of flat limestone slabs. The slabs are thin-bedded, medium-grained, gray limestone, are up to 2½ feet in length, and are elongate parallel to the bedding	1	....
Conglomerate, composed of limestone pebbles which are a maximum of ⅛ inch in diameter and are set in a gray limestone matrix	2	6
Total Fort Peña formation exposed	146	8
Alsate shale—		
Covered	110	....
Shale, black. COLLECTIONS 18 and 113: *Didymograptus affinis, Didymograptus mendicus, Didymograptus* sp., *Isograptus caduceus* var. *lunata, Phyllograptus typus, Tetragraptus amii*	16	6
Total Alsate shale	126	6
Marathon limestone—		
Upper part of Marathon limestone—		
Conglomerate, composed of limestone and chert pebbles. The conglomerate thins and intergrades with dark gray, sublithograptic limestone which weathers bluish gray northwestward along strike	1	....
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with flaggy, buff, calcareous, fine-grained limestone. A few medium-grained subgraywacke lenses which are ⅛ inch thick are interbedded with the flaggy, buff, calcareous limestone layers. Some of the flaggy, buff limestone layers bear mud		

	THICKNESS Feet	Inches
cracks. COLLECTION 19, from the top of this part of the section: *Didymograptus artus, Didymograptus bifidus, Phyllograptus ilicifolius,* conularid. The bed from which this collection was made is marked with yellow paint	14	6
Limestone, dark gray, sublithographic, weathering bluish gray. COLLECTION 20: *Didymograptus bifidus, Didymograptus protoindentus, Didymograptus denticulatus, Phyllograptus anna, Phyllograptus ilicifolius, Lingula* sp. The bed from which this collection was made is marked with yellow paint	....	6
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with flaggy, buff, calcareous limestone. COLLECTION 21, from base of this part of the section: *Didymograptus extensus*	14	....
Shale, flaggy, buff, calcareous. COLLECTION 22: *Callograptus* sp., *Tetragraptus decipiens* var. *bipatens*	1	6
Conglomerate, composed of flat chips and slabs of limestone	....	5
Shale, black	....	4
Limestone, dark gray, sublithographic, weathering bluish gray	....	7
Shale, black	....	4
Limestone, dark gray, sublithographic, weathering bluish gray	....	4
Fault		
Shale, black, interbedded with flaggy, buff, calcareous limestone and a few coarse-grained subgraywacke lenses which are ⅛ inch thick. COLLECTIONS 23 and 114: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus patulus, Didymograptus protobifidus, Didymograptus nitidus, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus fruticosus* (3- and 4-branched)	9	....
Shale, black, interbedded with flaggy, buff, calcareous limestone and buff calcareous shale. COLLECTION 115: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus leptograptoides, Didymograptus nicholsoni, Didymograptus patulus, Didymograptus protobifidus, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus* sp., *Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched)	8	6
At this point in the section, the shale and limestone are cut by several small faults.		
Below the shale, tightly folded, dark gray, sublithographic limestone which weathers bluish gray crops out. The folding is terminated by a fault. A 14-foot wide shatter zone is crossed, then the dark gray, sublithographic limestone is seen again to be tightly folded. The crest of a small anticline is cut by a fault, below which the section is again straightforward.		
Limestone, dark gray, sublithographic, weathering bluish gray, in layers 6 to 8 inches thick, interbedded with flaggy, buff, calcareous limestone. Graptolites were found throughout this 30-foot part of the section. COLLECTIONS 24A and 24B: *Didymograptus artus, Didymograptus bifidus, Didymograptus* sp.	30	....
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with flaggy, buff, calcareous limestone and buff, calcareous shale. *Didymograptus bifidus, Didymograptus bifidus—Didymograptus protobifidus* transient forms were collected from the upper 3 feet of this part of the section. COLLECTION 24F, from the lower 2½ feet of this part of the section: *Didymograptus protobifidus, Tetragraptus fruticosus* (3- and 4-branched)	8	6
Subgraywacke, brown, medium grained, calcareous	....	4
Shale, black, with some interbedded layers of flaggy, buff, calcareous shale and a few lenses of coarse-grained subgraywacke which are ⅛ inch thick. Graptolites were found throughout this part of the section. COLLECTION 25: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus patulus, Didymograptus protobifidus, Goniograptus thureaui, Phyllograptus anna, Phyllograptus anna* mut. *longus, Phyllograptus ilicifolius, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus pygmaeus, Tetragraptus quadribrachiatus, Tetragraptus serra, Tetragraptus reclinatus*	21	6
Fault		
Shale, buff, calcareous, interbedded with flaggy, buff, argillaceous limestone	3	....
Subgraywacke, brown, medium grained, calcareous	....	2
Limestone, flaggy, buff, argillaceous, interbedded with buff, calcareous shale. COLLECTION 26: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus nicholsoni* var. *planus, Didymograptus nitidus, Didymograptus patulus, Didymograptus similis, Phyllograptus angustifolius, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus amii, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3- and 4-branched), *Tetragraptus quadribrachiatus, Tetragraptus serra, Lingula* sp., *Protopliomerops* sp., chitinozoans	2	....
Conglomerate, composed of flat chips and slabs of limestone	4	....

Limestone, dark gray, sublithographic, weathering bluish gray in layers 8 to 10 inches thick interbedded with black shale. COLLECTION 27: *Callograptus* sp., *Didymograptus extensus, Tetragraptus fruticosus* (3- and 4-branched)	22	6
Conglomerate, composed of flat chips and slabs of limestone	2	3
Shale, black, interbedded with dark gray, sublithographic limestone which weathers bluish gray. COLLECTION 101: *Clonograptus* sp., *Dictyonema dumosus, Didymograptus nitidus, Tetragraptus fruticosus* (4-branched), conularid	7	....
Fault		
Monument Spring dolomite member—		
Limestone, dolomitic, blue and yellowish, fine grained, weathers orange, in oval lenses. Shale and thin-bedded, gray, fine-grained limestone lies around and between the lenses	60	....
Lower part of Marathon limestone—		
Covered	16	6
Limestone, dark gray, sublithographic, weathering bluish gray, interbedded with flaggy, buff, argillaceous limestone	34	....
Conglomerate, composed of flat chips and slabs of limestone	11	....
End of exposures in covered area.		

II. Collecting Localities

Following is a complete list of all the localities from which fossils were collected and a list of the species identified from each. The zone to which the assemblage belongs is indicated except in those cases where stratigraphic data were not sufficient to place it in the zonal sequence. All points are shown on Plate 1. This and King's (1937) geologic map of the Monument Spring and Marathon quadrangles should be used to correlate the fossil occurrences with geologic structure.

COLLECTION 1. Marathon limestone from 124½ feet above the base of Section III, measured on the southeast limb of the Marathon anticlinorium at a cairn built on the Roberts ranch road where the road turns southwest past Alsate Creek.

Lingula sp.

COLLECTION 2. Marathon limestone from 152¼ feet above Collection 1.

Zone 2: *Clonograptus* sp., *Clonograptus flexilis.*

COLLECTION 3. Marathon limestone 31 feet above Collection 2.

Acrotretid brachiopods.

COLLECTION 4. Marathon limestone from Section III, 20 feet above the Monument Spring dolomite member.

Zone 4: *Didymograptus extensus, Tetragraptus fruticosus* (4-branched).

COLLECTION 5. Marathon limestone 95½ feet above Collection 4.

Dictyonema sp., *Didymograptus* sp.

COLLECTION 6. Marathon limestone 200 feet southeast of the Roberts ranch road 1 mile southwest from a cairn built where the road turns southwest past Alsate Creek. This locality is 7.5 miles S. 54° W. in a direct line from Marathon.

Zone 1: *Anisograptus* sp., *Clonograptus* sp.

COLLECTION 7. Marathon limestone from an exposure in a gulley 50 feet S. 25° W. from Collection 6.

Zone 1: *Anisograptus* sp., *Lingula* sp.

COLLECTION 8. Alsate shale on low ridge southeast of the Roberts ranch road, half a mile southwest from a cairn built where the road turns southwest past Alsate Creek. This locality is 7.1 miles in a direct line S. 50° W. of Marathon.

Didymograptus affinis, Didymograptus sp., *Isograptus caduceus* var.?

COLLECTION 9. Marathon limestone 25 feet below Collection 8 and 14 feet below the top of the Marathon limestone.

Zone 7: *Didymograptus bifidus, Didymograptus bifidus—protobifidus* transient forms.

COLLECTION 10. Fort Peña formation 15 feet above its base on the low ridge on the southeast side of the Roberts ranch road, 2 miles southwest from a cairn built where the road bends southwest past Alsate Creek. This locality is 8.6 miles in a direct line S. 50° W. of Marathon.

Zone 8: *Glyptograptus* cf. *G. austrodentatus, Isograptus caduceus* var. *victoriae.*

COLLECTION 11. Marathon limestone 83 feet above the base of Section IV, in a creek bed on the south side of U.S. Highway 90, 1 mile west of the railroad station in Marathon.

Zone 2: *Adelograptus hunnebergensis?, Clonograptus flexilis, Clonograptus rigidus.*

COLLECTION 12. Marathon limestone 32½ feet above Collection 11.

Zone 2: *Clonograptus persistens, Clonograptus* sp.

COLLECTION 13. Fort Peña formation 17 inches below the top of Section XVIII, in the bed of Alsate Creek 3 miles west of the Picnic Grounds (Pl. 1).

Zone 9: *Callograptus* sp., *Cryptograptus schaferi, Glossograptus acanthus, Glossograptus hincksii, Glyptograptus intersitus, Isograptus ovatus, Hallograptus echinatus, Hallograptus etheridgei, Loganograptus logani, Tetragraptus quadribrachiatus, Trigonograptus ensiformis, Retiograptus speciosus?*

COLLECTION 14. Fort Peña formation 11 feet 10 inches below Collection 13.

Zone 9: *Callograptus* sp., *Cryptograptus schaferi, Dichograptus marathonensis, Didymograptus cuspidatus. Glossograptus acanthus, Glyptograptus* sp., *Hallograptus etheridgei, Tetragraptus quadribrachiatus.*

COLLECTION 15. Fort Peña formation 12 feet 10 inches below Collection 14.

Zone 9: *Callograptus* sp., *Cryptograptus schaferi, Didymograptus* sp., *Glossograptus hystrix, Glyptograptus* cf. *G. austrodentatus, Glyptograptus intersitus, Isograptus caduceus* var. *divergens, Isograptus forcipiformis* var. *latus, Hallograptus etheridgei, Tetragraptus quadribrachiatus, Trigonograptus ensiformis.*

COLLECTION 16. Fort Peña formation 4 feet 2 inches below Collection 15.

Zone 9: *Didymograptus cuspidatus, Didymograptus nodosus, Glossograptus* sp., *Glyptograptus intersitus, Isograptus forcipiformis* var. *latus, Pterograptus incertus.*

COLLECTION 17. Fort Peña formation 5 feet 2 inches below Collection 16.

Zone 9: *Isograptus caduceus* var.?

COLLECTION 18. Alsate shale 5 feet above the base of the formation in Section XVIII.
Zone 8: *Didymograptus affinis, Didymograptus mendicus, Didymograptus* sp., *Isograptus caduceus* var. *lunata, Phyllograptus typus, Tetragraptus amii.*

COLLECTION 19. Marathon limestone 2 feet below the top of the formation in Section XVIII.
Zone 7: *Didymograptus artus, Didymograptus bifidus, Phyllograptus ilicifolius,* conularid.

COLLECTION 20. Marathon limestone 12½ feet below Collection 19.
Zone 7: *Didymograptus bifidus, Didymograptus protoindentus, Didymograptus denticulatus, Phyllograptus anna, Phyllograptus ilicifolius, Lingula* sp.

COLLECTION 21. Marathon limestone 14½ feet below Collection 20.
Didymograptus extensus.

COLLECTION 22. Marathon limestone 1½ feet below Collection 21.
Zone 6: *Callograptus* sp., *Tetragraptus decipiens* var. *bipatens.*

COLLECTION 23. Marathon limestone 8 feet below a fault which is 2 feet below Collection 22.
Zone 6: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus patulus, Didymograptus protobifidus, Didymograptus nitidus, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus fruticosus* (3- and 4-branched).

COLLECTIONS 24A and 24B. Marathon limestone from 15 to 25 feet below a prominent shatter zone and fault that are 9½ feet below Collection 23.
Zone 7: *Didymograptus artus, Didymograptus bifidus, Didymograptus* sp.

COLLECTION 24F. Marathon limestone 7 feet below Collections 24A and 24B.
Zone 6: *Didymograptus protobifidus, Tetragraptus fruticosus* (3-branched).

COLLECTION 25. Marathon limestone 12 feet below Collection 24F.
Zone 6: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus patulus Didymograptus protobifidus, Goniograptus thureaui, Phyllograptus anna, Phyllograptus anna* mut. *longus, Phyllograptus ilicifolius, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus pygmaeus, Tetragraptus quadribrachiatus, Tetragraptus serra, Tetragraptus reclinatus.*

COLLECTION 26. Marathon limestone 3 feet 2 inches below a fault that is 11½ feet below Collection 25.
Zone 5: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus nicholsoni* var. *planus, Didymograptus nitidus, Didymograptus patulus, Didymograptus similis, Phyllograptus angustifolius, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus amii, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3- and 4-branched), *Tetragraptus quadribrachiatus, Tetragraptus serra, Lingula* sp., *Protopliomerops* sp., chitinozoans.

COLLECTION 27. Marathon limestone 8 feet below Collection 26.
Zone 5: *Callograptus* sp., *Didymograptus extensus, Tetragraptus fruticosus* (3- and 4-branched).

COLLECTION 28. Fort Peña formation from an outcrop on State Highway 51, 1.5 miles south of its junction with U.S. Highway 90.
Zone 9: *Brachiograptus etaformis, Cryptograptus schaferi, Dichograptus marathonensis, Dichograptus octobrachiatus, Didymograptus compressus, Didymograptus nodosus, Glossograptus hincksii, Glossograptus horridus, Glyptograptus* cf. *G. austrodentatus, Glyptograptus intersitus, Isograptus forcipiformis* var. *latus, Loganograptus logani, Loganograptus logani* mut. *pertenuis, Pterograptus incertus, Ptilograptus plumosus, Tetragraptus quadribrachiatus, Tetragraptus serra, Trichograptus immotus, Trigonograptus ensiformis.*

COLLECTION 29. Marathon limestone 80 feet below Collection 11, which is in Section IV.
Zone 1: *Anisograptus* sp., *Triograptus* cf. *T. otagoensis, Dictyonema* sp.

COLLECTION 30. Marathon limestone 106 feet above Collection 5 in Section III.
Zone 6: *Didymograptus protobifidus, Phyllograptus ilicifolius, Phyllograptus angustifolius. Tetragraptus quadribrachiatus.*

COLLECTION 31. Monument Spring dolomite member of the Marathon limestone in Section III.
Zone 3: *Archeoscyphia* sp., fragments of orthoid brachiopods, cephalopods, and gastropods.

COLLECTION 32. Marathon limestone on a rise 200 yards west of the Roberts ranch road, 1.2 miles southwest from a cairn built where the road turns southeast past Alsate Creek.
Didymograptus extensus, Didymograptus patulus.

COLLECTION 33. Marathon limestone from 318 feet above the base of the formation in Section I, measured southwest of Marathon.
Zone 2: *Adelograptus simplex, Adelograptus victoriae, Bryograptus crassus?, Clonograptus flexilis, Clonograptus persistens.*

COLLECTION 34. Marathon limestone from 264 feet above the base of the formation in Section I.
Zone 2: *Ophileta* sp., *Pachendoceras* sp.

COLLECTION 35. Dagger Flat sandstone from a low ridge 2½ miles east-northeast of the Buttrill ranch.
Fragments of inarticulate brachiopods and chitinous cones.

COLLECTION 36. Marathon limestone 3¼ miles east-northeast of the Buttrill ranch.
Didymograptus nitidus, acrotretid brachiopods.

COLLECTION 37. Marathon limestone from 142 feet above the base of Section VII, measured on the southeast limb of the Dagger Flat anticlinorium at a locality 2½ miles east-northeast of the Buttrill ranch.
Zone 2: *Adelograptus simplex, Bryograptus crassus?, Clonograptus* sp.

COLLECTION 38. Woods Hollow shale 3 miles N. 50° E. of Woods Hollow Tank and at the base of the mountain with elevation of 4,305 feet.

Zone 10: *Amplexograptus confertus, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 39. Marathon limestone 3 miles N. 50° E. of Woods Hollow Tank 2,500 feet southeast of Collection 38.

Didymograptus nitidus?, Didymograptus nicholsoni, Didymograptus cf. *D. extensus,* a new genus of trilobite related to *Strigenalis* and *Benthamaspis.*

COLLECTION 40. Marathon limestone from 33 feet below its contact with the Alsate shale at the locality of Section VII.

Zone 6: *Didymograptus extensus, Didymograptus protobifidus, Goniograptus* sp., *Phyllograptus angustifolius, Phyllograptus ilicifolius, Tetragraptus amii, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus pygmaeus, Tetragraptus quadribrachiatus.*

COLLECTION 40A. Marathon limestone from 32 feet below its contact with the Alsate shale, 170 feet N. 50° E. from Collection 40.

Zone 6: *Didymograptus protobifidus, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus quadribrachiatus.*

COLLECTION 41. Fort Peña formation from the nose of a small fold 2⅛ miles N. 70° E. of Buttrill ranch.

Acrotretid brachiopod fragments.

COLLECTION 42. Fort Peña formation from the nose of a small fold 2¼ miles N. 72° E. of Buttrill ranch.

Cardiograptus crawfordi, Cardiograptus morsus, Glyptograptus sp., *Hallograptus echinatus, Isograptus caduceus* var. *imitata.*

COLLECTION 43. Marathon limestone 168 feet above Collection 37 in Section VII.

Zone 2: *Adelograptus victoriae, Clonograptus* sp.

COLLECTION 44. Fort Peña formation in a small fold 500 yards northeast of Collection 43.

Glyptograptus sp., fragments of acrotretid brachiopods.

COLLECTION 45. Maravillas chert; from 77 feet below its contact with the Caballos novaculite in Section XVI, measured on the northwest limb of the Dagger Flat anticlinorium 2 miles N. 55° E. of Woods Hollow Tank.

Zone 14: *Climacograptus* sp., *Climacograptus tubuliferus, Diplograptus minutus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Orthograptus quadrimucronatus, Orthograptus truncatus* var. *recurrens, Retiograptus pulcherrimus.*

COLLECTION 46. Woods Hollow shale in a folded area at the base of the hill with an elevation of 4,305 feet 2 miles N. 55° E. of Woods Hollow Tank.

Zone 10: *Amplexograptus confertus, Amplexograptus* cf. *A. differtus, Climacograptus riddellensis, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 46A. Woods Hollow shale from 22 feet 10 inches above its contact with the Fort Peña formation in Section XI, measured on the southeast side of the anticlinal valley in which the old Louis Granger place was located.

Zone 10: *Amplexograptus confertus, Climacograptus riddellensis, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 47. Marathon limestone in a small anticline 2 miles N. 55° E. of Woods Hollow Tank.

Zone 7: *Didymograptus artus, Didymograptus bifidus, Didymograptus similis, Goniograptus perflexilis, Phyllograptus anna, Phyllograptus typus, Tetragraptus bigsbyi, Tetragraptus quadribrachiatus, Tetragraptus serra.*

COLLECTION 48. Marathon limestone 650 feet southeast of Collection 47.

Zone 4: *Didymograptus ellesae, Didymograptus extensus, Tetragraptus acclinans, Tetragraptus quadribrachiatus, Trochograptus lapworthi.*

COLLECTION 49. Woods Hollow shale 12 feet above the base of the formation 1¼ miles west of Gage's Lightning ranch.

Zone 11: *Cryptograptus tricornis, Dicellograptus sextans, Leptograptus flaccidus* mut. *trentonensis.*

COLLECTION 50. Fort Peña formation 2 miles S. 80° W. of Gage's Lightning ranch.

Didymograptus sp., *Isograptus* sp., *Lingula* sp., acrotretid brachiopod.

COLLECTION 51. Maravillas chert 203 feet below its contact with the Caballos novaculite in Section XVII, measured on the north slope of Threemile Hill.

Zone 14: *Cryptolithus* sp., *Flexicalymene* sp., *Hallopora* sp.

COLLECTION 52. Marathon limestone from a fault slice at the base of the north face of Threemile Hill.

Zone 6: *Didymograptus extensus, Didymograptus protobifidus, Didymograptus protobifidus—Didymograptus bifidus* transient forms, *Phyllograptus angustifolius, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus bigsbyi. Tetragraptus fruticosus* (3-branched), *Tetragraptus quadribrachiatus, Tetragraptus serra, Tetragraptus taraxacum.*

COLLECTION 53. Marathon limestone 25 feet above the base of the formation in Section I.

Zone 1: *Anisograptus* sp.

COLLECTION 54. Maravillas chert 200 feet below its contact with the Caballos novaculite one-fourth mile northeast of Maravillas Creek at Maravillas Gap.

Zone 14: *Climacograptus* sp., *Climacograptus minimus, Orthograptus* cf. *O. calcaratus* var. *basilicus.*

COLLECTION 55. Maravillas chert 50 feet above Collection 54.
Zone 14: *Climacograptus* sp., *Climacograptus minimus, Climacograptus tubuliferus, Orthograptus quadrimucronatus, Retiograptus pulcherrimus.*

COLLECTION 56. Marathon limestone ⅝ mile northeast of the junction of Woods Hollow Creek with Maravillas Creek, near Maravillas Gap.
Zone 1: *Anisograptus* sp., *Clonograptus* sp.

COLLECTION 57. Maravillas chert 100 feet below its contact with the Caballos novaculite, half a mile southwest of the junction of Woods Hollow Creek with Maravillas Creek, near Maravillas Gap. Fragments of bryozoa.

COLLECTION 58. Maravillas chert 30 feet above Collection 57.
Climacograptus sp., fragments of bryozoa.

COLLECTION 59. Marathon limestone from 2 feet above the base of Section IX, measured on the southeast limb of the Marathon anticlinorium, one-fourth mile southeast of the Roberts ranch road, three-fourths of a mile southwest from a cairn built where the road turns southwest past Alsate Creek.
Zone 2: *Adelograptus hunnebergensis?, Clonograptus* sp.

COLLECTION 60. Maravillas chert half an inch below its contact with the Caballos novaculite in Section XV, measured on the cliff rising above the Picnic Grounds 5 miles south-southwest of Marathon.
Zone 15: *Dicellograptus complanatus, Dicellograptus complanatus* var. *arkansasensis, Dicellograptus complanatus* var. *ornatus, Diplograptus crassitestus, Climacograptus hastatus, Climacograptus mississippiensis, Climacograptus putillus, Orthograptus truncatus* var. *socialis, Retiograptus deckeri.*

COLLECTION 61A. Fort Peña formation 4 miles S. 50° W. of Peña Blanca Spring and 3½ miles S. 87° W. of Woods Hollow Tank.
Zone 8: *Cardiograptus crawfordi, Didymograptus paraindentus, Isograptus caduceus* var. *maxima, Isograptus manubriatus.*

COLLECTION 61B. Fort Peña formation 10 feet below Collection 61A.
Zone 8: *Didymograptus cuspidatus, Oncograptus upsilon.*

COLLECTION 62. Fort Peña formation 186 feet northwest of Collection 61A.
Zone 8: *Callograptus* sp., *Cardiograptus crawfordi, Trigonograptus ensiformis.*

COLLECTION 63. Marathon limestone 328 feet northwest of Collection 62.
Zone 6: *Callograptus* sp., *Didymograptus protobifidus—Didymograptus bifidus* transient forms, *Phyllograptus anna, Phyllograptus angustifolius, Phyllograptus typus, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus reclinatus, Tetragraptus serra.*

COLLECTION 64. Marathon limestone 107 feet northwest of Collection 63.
Zone 6: *Didymograptus protobifidus, Didymograptus similis, Tetragraptus bigsbyi, Tetragraptus fruticosus* (3-branched), *Tetragraptus taraxacum.*

COLLECTION 65A. Marathon limestone 375 feet northwest of Collection 64.
Zone 6: *Phyllograptus anna, Tetragraptus* sp.

COLLECTION 65B. Marathon limestone 62 feet northwest of Collection 65A.
Zone 6: *Tetragraptus fruticosus* (3-branched), *Tetragraptus quadribrachiatus.*

COLLECTION 65C. Marathon limestone 43 feet northwest of Collection 65B.
Zone 6: *Didymograptus extensus, Didymograptus* sp., *Phyllograptus anna, Phyllograptus typus.*

COLLECTION 65D. Marathon limestone 220 feet northwest of Collection 65C.
Zone 7: *Didymograptus bifidus, Didymograptus* sp., *Phyllograptus typus.*

COLLECTION 66. Marathon limestone from 52½ feet above the Monument Spring dolomite member in Section II, measured on the east side of a gap between ridges of Marathon limestone, 2.8 miles southwest from a cairn built on the Roberts ranch road where the road turns southwest past Alsate Creek.
Zone 5: *Didymograptus extensus, Didymograptus nicholsoni, Didymograptus nitidus, Tetragraptus fruticosus* (4-branched).

COLLECTION 66A. Marathon limestone 173 feet above Collection 66.
Zone 7: *Didymograptus bifidus.*

COLLECTION 67. Marathon limestone 212 feet above the base of Section V, measured across the Roberts ranch road 2¾ miles southwest from a cairn built where the road turns southwest past Alsate Creek.
Zone 7: *Didymograptus bifidus, Didymograptus similis, Phyllograptus anna, Phyllograptus typus.*

COLLECTION 68. Marathon limestone 89 feet below Collection 67.
Zone 6: *Didymograptus nicholsoni, Didymograptus nitidus, Didymograptus patulus.*

COLLECTION 69. Marathon limestone 114 feet below Collection 68.
Zone 4: *Clonograptus flexilis, Dichograptus octobrachiatus, Didymograptus nicholsoni* var. *planus, Didymograptus nitidus, Didymograptus* cf. *D. patulus, Didymograptus* sp., *Tetragraptus amii, Tetragraptus fruticosus* (4-branched), *Tetragraptus quadribrachiatus.*

COLLECTION 70. Marathon limestone 3 feet below its contact with the Alsate shale in a roadcut on State Highway 51, 1 mile north of the Buttrill ranch road entrance.

Zone 7: *Didymograptus bifidus, Didymograptus similis, Didymograptus* sp., *Isograptus caduceus* var. *lunata, Phyllograptus typus.*

COLLECTION 71. Marathon limestone in the bed of Dugout Creek, 1 mile north of the Roberts ranch buildings.

Zone 4: *Adelograptus pusillus, Clonograptus* sp., *Didymograptus nitidus, Didymograptus* sp., *Phyllograptus ilicifolius, Tetragraptus amii, Tetragraptus bigsbyi, Tetragraptus fruticosus* (4-branched), *Tetragraptus pendens, Tetragraptus quadribrachiatus.*

COLLECTION 72A. Marathon limestone 15 feet above the base of Section VIII, measured on the southeast limb of the Marathon anticlinorium, on the southeast side of the Roberts ranch road, 0.8 mile south of a cairn built where the road turns southwest past Alsate Creek.

Zone 1: *Anisograptus* sp.

COLLECTION 72B. Marathon limestone 92 feet above Collection 72A.

Zone 1: *Anisograptus* sp., *Clonograptus* cf. *C. tenellus, Dictyonema* sp.

COLLECTION 72C. Marathon limestone 85 feet above Collection 72B.

Zone 2: *Clonograptus* sp., *Didymograptus novus.*

COLLECTION 72D. Marathon limestone from the southeast limb of a small drag fold on which Section VIII ended.

Clonograptus sp., *Didymograptus novus, Triograptus* cf. *T. otagoensis.*

COLLECTION 72E. Marathon limestone from 57¼ feet above the base of Section IX measured on the southeast limb of the Marathon anticlinorium, one-fourth mile southeast of the Roberts ranch road, three-fourths of a mile southwest from a cairn built where the road turns southwest past Alsate Creek.

Zone 2: *Adelograptus simplex, Adelograptus victoriae, Anisograptus* sp., *Dictyonema* sp., *Didymograptus novus, Tetragraptus decipiens.*

COLLECTION 73. Maravillas chert 20 feet above the base of the formation in Section XIV, measured at Rock House Gap near the southwestern end of the southeast limb of the Marathon anticlinorium.

Zone 13: *Climacograptus antiquus, Climacograptus scharenbergi, Climacograptus typicalis, Dicranograptus nicholsoni* var. *geniculatus, Orthograptus quadrimucronatus* var. *angustus, Orthograptus truncatus* var. *intermedius, Retiograptus pulcherrimus.*

COLLECTION 73A. Maravillas chert 53 feet above Collection 73.

Zone 14: *Orthograptus quadrimucronatus.*

COLLECTION 74. Marathon limestone 55 feet above Collection 34 in Section I.

Zone 2: *Adelograptus victoriae, Clonograptus* sp.

COLLECTION 75. Marathon limestone 80 feet above Collection 33 in Section I.

Zone 2: *Adelograptus* sp., *Dendrograptus* sp.

COLLECTION 76. Monument Spring dolomite member of the Marathon limestone in Section I.

Zone 3: *Clonograptus flexilis, Clonograptus rigidus, Tetragraptus approximatus.*

COLLECTION 77. Monument Spring dolomite member of the Marathon limestone from a low ridge in a folded area 62 feet northwest of Collection 78.

Zone 3: *Clonograptus* sp., *Tetragraptus approximatus.*

COLLECTION 78. Monument Spring dolomite member of the Marathon limestone 12 feet above Collection 76 in Section I.

Zone 3: *Endoceras* sp., *Shumardoceras* sp.

COLLECTION 79. Marathon limestone 22 feet above the Monument Spring dolomite member in Section I.

Zone 4: *Dictyonema* sp., *Didymograptus extensus, Didymograptus nitidus,* a new genus of trilobite related to *Benthamaspis* and *Strigenalis.*

COLLECTION 80. Monument Spring dolomite member of the Marathon limestone 177 feet above Collection 72E in Section IX.

Zone 3: *Clonograptus* sp., *Dichograptus octobrachiatus, Tetragraptus approximatus.*

COLLECTION 81. Fort Peña formation 2 feet below its contact with the Woods Hollow shale three-eighths mile N. 18° E. of Roberts ranch road, 1.4 miles southwest from a cairn built where the road turns southwest past Alsate Creek. This locality is 8 miles S. 55° W. in a direct line from Marathon.

Zone 10: *Amplexograptus confertus, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 82. Fort Peña formation 50 feet below Collection 81.

Zone 9: *Hallograptus* sp., *Retiograptus* sp., *Leperditella* sp., *Paraschmidtella perforata.*

COLLECTION 83A. Maravillas chert near the base of the ridge half a mile east of the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 14: *Climacograptus* sp., *Climacograptus minimus, Leptograptus annectans, Orthograptus calcaratus?, Orthograptus* cf. *O. calcaratus* var. *basilicus, Orthograptus quadrimucronatus, Orthograptus* aff. *O. truncatus, Diplograptus* sp.

COLLECTION 83B. Maravillas chert on top of the ridge half a mile east of the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 14: *Climacograptus minimus, Climocograptus tubuliferus, Dicellograptus forchammeri?, Orthograptus quadrimucronatus, Orthograptus* aff. *O. truncatus, Retiograptus pulcherrimus.*

COLLECTION 84. Marathon limestone 83 feet above the base of Section VI, measured on the southeast limb of the Marathon anticlinorium on the southeast side of the Roberts ranch road, 0.4 mile southwest of a cairn built where the road turns southwest past Alsate Creek.

Zone 2: *Callograptus* sp., *Clonograptus rigidus, Clonograptus tenellus* var. *callavei, Dictyonema* sp., *Didymograptus* sp., *Tetragraptus decipiens, Triograptus* cf. *T. otagoensis.*

COLLECTION 84A. Marathon limestone one-eighth mile southeast of Collection 84, near the nose of a small fold.

Zone 1: *Anisograptus dissolutus.*

COLLECTION 85. Fort Peña formation on northeast face of a low ridge, 3.3 miles N. 86° W. of the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 10: *Amplexograptus confertus, Amplexograptus* cf. *A. differtus, Glyptograptus* cf. *G. teretiusculus, Phyllograptus nobilis.*

COLLECTION 86A. Maravillas chert 58¼ feet below its contact with the Caballos novaculite in Section XV, measured on the cliff rising above the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 14: *Climacograptus minimus, Climacograptus tubuliferus, Orthograptus quadrimucronatus?.*

COLLECTION 86B. Maravillas chert 139 feet below Collection 86A.

Zone 13: *Climacograptus spiniferus, Climacograptus* sp., *Orthograptus quadrimucronatus* var. *angustus, Orthograptus truncatus* var. *intermedius, Orthograptus* aff. *O. truncatus, Retiograptus pulcherrimus.*

COLLECTION 87. Woods Hollow shale 25 feet below its contact with the Maravillas chert in a small anticlinal valley south of the Right Hand Shut Up in the southwest quadrant of the Solitario.

Zone 12: *Amplexograptus* cf. *A. perexcavatus, Climacograptus bicornis, Diplograptus multidens, Diplograptus multidens* var. *diminutus, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *euglyphus, Hallograptus mucronatus, Orthograptus calcaratus* var. *acutus.*

COLLECTION 88. Fort Peña formation 2 inches above its contact with the Rodriquez Tank sandstone, one-fourth mile northwest of Rodriquez Tank in the Solitario.

Zone 8: *Isograptus caduceus* var. *maxima, Isograptus caduceus* var. *maximo-divergens.*

COLLECTION 89. Marathon limestone from a gulley that cuts across a small anticline, 1 mile northeast of the Right Hand Shut Up in the Solitario.

Zone 2: *Adelograptus victoriae, Didymograptus* sp., *Tetragraptus* sp.

COLLECTION 90. Marathon limestone from a gulley north of a water trough on a low ridge half a mile N. 80° W. of Rodriquez Tank, in the Solitario.

Zone 5: *Didymograptus extensus, Didymograptus nicholsoni* var. *planus, Didymograptus nitidus, Tetragraptus fruticosus* (3- and 4-branched), *Tetragraptus taraxacum, Tetragraptus pygmaeus.*

COLLECTION 91. Marathon limestone 90 feet below its contact with the Alsate shale 1⅜ miles N. 10° E. of the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 5: *Didymograptus extensus, Didymograptus nitidus, Didymograptus patulus.*

COLLECTION 92. Fort Peña formation 15 feet below its contact with the Woods Hollow shale in Section XI, measured on the southeast side of the anticlinal valley in which the old Louis Granger place is located.

Zone 10: *Amplexograptus confertus, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 93. Maravillas chert from a roadcut on State Highway 51, 12 miles south of its junction with U. S. Highway 90.

Zone 14: *Climacograptus* sp., *Climacograptus tubuliferus, Dicellograptus forchammeri?, Orthograptus* sp.

COLLECTION 94A. Woods Hollow shale in the Payne Hills, 8.4 miles S. 75° W. of Marathon.

Zone 12: *Climacograptus bicornis, Climacograptus antiquus* var. *bursifer, Climacograptus eximius, Climacograptus modestus, Climacograptus parvus, Corynoides calicularis, Cryptograptus tricornis, Didymograptus sagitticaulis, Didymograptus serratulus, Glossograptus ciliatus?, Glyptograptus teretiusculus* var. *euglyphus, Glyptograptus teretiusculus* var. *pygmaeus, Diplograptus multidens* var. *diminutus, Hallograptus mucronatus, Leptograptus validus* var. *incisus?, Orthograptus calcaratus* var. *acutus, Orthograptus calcaratus* var. *alabamensis, Orthograptus whitfieldi, Retiograptus geinitzianus.*

COLLECTION 94B. Woods Hollow shale 10 feet above Collection 94A.

Zone 12: *Climacograptus modestus, Climacograptus parvus, Cryptograptus tricornis, Glyptograptus teretiusculus* var. *euglyphus, Hallograptus bimucronatus, Hallograptus mucronatus.*

COLLECTION 94C. Woods Hollow shale 8 feet above Collection 94B.

Zone 12: *Climacograptus antiquus* var. *bursifer, Climacograptus modestus, Didymograptus sagitticaulis, Diplograptus multidens* var. *diminutus, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *euglyphus.*

COLLECTION 95. Fort Peña formation 5 feet above the base of the formation in Section II.

Zone 8: *Dichograptus* sp., *Glyptograptus* cf. *G. austrodentatus, Isograptus caduceus* var. *maxima, Isograptus caduceus* var. *victoriae, Tetragraptus quadribrachiatus.*

COLLECTION 96. Fossils from the core of nodules found in the basal 2 inches of shale in the lower member of the Santiago formation exposed in the manganese prospect on Rough Creek about one mile north of its junction with San Francisco Creek.

Climacograptus sp., *Glyptograptus* sp., nautiloid fragments, brachiopod fragments.

COLLECTION 97A. Marathon limestone 25 feet above the base of the formation half a mile southeast of the Roberts ranch road 2½ miles southwest from a cairn built where the road turns southwest past Alsate Creek. This locality is 9 miles in a direct line S. 53° W. of Marathon.

Zone 1: *Anisograptus* sp.

COLLECTION 97B. Marathon limestone 320 feet above Collection 97A.

Dictyonema sp., *Clonograptus flexilis.*

COLLECTION 98. Fort Peña formation in a roadcut 1.5 miles south of Marathon on the road to the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 9: *Didymograptus cuspidatus, Didymograptus nodosus, Didymograptus* sp., *Cryptograptus schaferi, Glossograptus hystrix, Hallograptus echinatus, Retiograptus tentaculatus?, Trigonograptus ensiformis, Tetragraptus quadribrachiatus, Trichograptus immotus.*

COLLLECTION 98A. Fort Peña formation from the crest of the low ridge one-eighth mile southeast of Collection 98.

Zone 8: *Glyptograptus* cf. *G. austrodentatus, Isograptus caduceus* var. *victoriae.*

COLLECTION 99. Maravillas chert 13 feet above the base of the formation in Section XII, measured three-eighth mile northeast of the Picnic Grounds (5 miles south-southwest of Marathon) on the ridge which trends northeast from these grounds.

Zone 13: *Orthograptus* sp., *Ampyxina* sp.

COLLECTION 100. Woods Hollow shale 19½ feet below its contact with the Maravillas chert in Section XII.

Zone 12: *Dicellograptus sextans, Didymograptus serratulus, Glyptograptus teretiusculus* var. *euglyphus, Orthograptus calcaratus* var. *alabamensis, Cryptograptus tricornis.*

COLLECTION 101. Marathon limestone 30 feet below Collection 27 in Section XVIII.

Zone 4: *Clonograptus* sp., *Dictyonema dumosus, Didymograptus nitidus, Tetragraptus fruticosus* (4-branched), conularid.

COLLECTION 102. Marathon limestone on a low ridge 200 yards southeast of the Roberts ranch road, 3.2 miles southwest from a cairn built where the road turns southwest past Alsate Creek. This locality is 9.8 miles S. 54° W. of Marathon.

Didymograptus patulus, Didymograptus cf. *D. patulus.*

COLLECTION 103. Woods Hollow shale 89 feet below its contact with the Maravillas chert in Section XI.

Zone 12: *Climacograptus bicornis, Climacograptus eximius, Corynoides tricornis, Cryptograptus tricornis, Dicellograptus sextans.*

COLLECTION 104. Woods Hollow shale from an outcrop on State Highway 51, 17.8 miles south of its junction with U. S. Highway 90.

Zone 11: *Corynoides calicularis, Corynoides incurvus, Cryptograptus tricornis, Dicellograptus divaricatus, Dicellograptus intortus, Dicellograptus sextans* var. *exilis, Dicranograptus brevicaulis, Dicranograptus contortus, Didymograptus serratulus, Glossograptus ciliatus?, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *euglyphus, Leptograptus validus* var. *incisus?, Nemagraptus exilis* var. *linearis.*

COLLECTION 105. Woods Hollow shale 12 feet below its contact with the Maravillas chert in Section XII.

Zone 12: *Corynoides incurvus, Cryptograptus tricornis, Dicellograptus sextans, Didymograptus serratulus, Orthograptus whitfieldi, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *pygmaeus.*

COLLECTION 106. Maravillas chert 5 feet above the base of the formation at the base of the cliff face one-fourth mile northeast of the Picnic Grounds 5 miles south-southwest of Marathon.

Zone 13: *Climacograptus antiquus, Climacograptus typicalis* var. *crassimarginalis, Orthograptus calcaratus* var. *incisus.*

COLLECTION 107. Fort Peña formation near its base on an anticlinal ridge 1⅝ miles S. 50° E. of Marathon.

Zone 8: *Cardiograptus morsus, Didymograptus pacificus, Isograptus caduceus* var. *maxima, Oncograptus upsilon.*

COLLECTION 108. Woods Hollow shale 50 feet below its contact with the Maravillas chert in the gulley on the northeast end of East Bourland Mountain.

Zone 12: *Climacograptus* sp., *Cryptograptus* sp., *Diplograptus* sp.

COLLECTION 109. Limestone boulder from the shale layer from which Collection 108 was made.

Aphelaspis sp., *Pseudagnostus* sp.

COLLECTION 110. Fort Peña formation 1 foot above the base of the formation, 2 miles S. 16° E. of the old Jones ranch headquarters (now Slaughter's ranch) in a deep arroyo heading in the Cretaceous rim.

Zone 8: *Didymograptus euodus, Isograptus caduceus* var. *divergens, Isograptus caduceus* var. *maxima, Isograptus caduceus* var. *victoriae, Isograptus manubriatus, Oncograptus upsilon, Tetragraptus quadribrachiatus.*

COLLECTION 110A. Maravillas chert on ridge one-fourth mile northwest of Collection 110.

Climacograptus sp., *Orthograptus* sp.

COLLECTION 111. Fort Peña formation 100 feet below its contact with the Woods Hollow shale on a low ridge seven-eighths of a mile S. 5° W. of Woods Hollow Tank.

Zone 9: *Isograptus caduceus* aff. var. *divergens, Isograptus manubriatus, Tetragraptus quadribrachiatus.*

COLLECTION 112. Fort Peña formation on the crest of an anticline which forms a low ridge 1⅝ miles S. 25° E. of Marathon.

Didymograptus sp., *Glyptograptus* cf. *G. austrodentatus.*

COLLECTION 113. Alsate shale from the same locality as Collection 18.

COLLECTION 114. Marathon limestone from the same locality as Collection 23.

COLLECTION 115. Marathon limestone 8 feet below Collections 23 and 114 in Section XVIII.

Zone 6: *Dichograptus octobrachiatus, Didymograptus extensus, Didymograptus leptograptoides, Didymograptus nicholsoni, Didymograptus patulus, Didymograptus protobifidus, Phyllograptus anna, Phyllograptus ilicifolius, Tetragraptus bigsbyi, Tetragraptus fruticosus* 3- and 4-branched), *Tetragraptus* sp.

COLLECTION 116. Monument Spring dolomite member of the Marathon limestone from the low ridge capped by dolomitic limestone of the member, southeast of the Roberts ranch road one-eighth mile northeast of a cairn built where the road turns southwest past Alsate Creek.

Zone 3: *Archeoscyphia* aff. *A. annulatum.*

COLLECTION 117. Fort Peña formation 96 feet above the base of the formation in Section X, measured across a ridge of the formation 2½ miles west-southwest of the Picnic Grounds (5 miles south-southeast of Marathon) on the southeast side of the Roberts ranch road southeast of a cairn built where the road turns southwest past Alsate Creek.

Zone 9: *Glyptograptus* cf. *G. austrodentatus, Hallograptus etheridgei.*

COLLECTION 117A. Fort Peña formation 35 feet above Collection 117.

Zone 9: *Glyptograptus* cf. *G. austrodentatus.*

COLLECTION 118. Marathon limestone 199 feet above the base of the formation in Section II.

Zone 1: *Bellefontia* sp., *Lloydia* sp.

COLLECTION 119. Marathon limestone 70 feet above the base of the formation in Section II.

Zone 1: *Anisograptus* sp., *Clonograptus* cf. *C. tenellus.*

COLLECTION 120. Monument Spring dolomite member of the Marathon limestone 342 feet 4 inches above Collection 118.

Zone 3: *Tetragraptus approximatus, Tetragraptus bigsbyi, Tetragraptus quadribrachiatus, Tetragraptus taraxacum, Didymograptus extensus, Clonograptus flexilis.*

COLLECTION 121. Marathon limestone 12 feet above the Monument Spring dolomite member in Section II (51½ feet above Collection 120).

Zone 4: *Didymograptus nitidus, Dictyonema* sp., *Tetragraptus fruticosus* (4-branched), *Tetragraptus quadribrachiatus, Ptilograptus plumosus.*

COLLECTION 122. Woods Hollow shale 167½ feet below its contact with the Maravillas chert in Section XIII, measured 2½ miles, in a straight line, southwest of the Picnic Grounds (5 miles south-southwest of Marathon) on the northeastern bend in the ridge southeast of the Sunshine Springs thrust fault.

Zone 11: *Climacograptus scharenbergi* cf. var. *stenostoma, Corynoides calicularis, Cryptograptus tricornis, Dicellograptus divaricatus, Dicellograptus gurleyi, Dicellograptus intortus, Dicellograptus sextans, Dicellograptus smithi, Dicranograptus brevicaulis, Nemagraptus gracilis, Retiograptus geinitzianus.*

COLLECTION 123. Woods Hollow shale 14 feet above Collection 122.

Aparchites sp., *Eurychilina papillata.*

COLLECTION 124. Woods Hollow shale 15 feet above Collection 123.

Climacograptus sp., *Corynoides* sp., *Glyptograptus* sp.

COLLECTION 125. Woods Hollow shale 243 feet below its contact with the Maravillas chert in a gulley one-fourth mile southeast from the gulley in which Section XIII was measured.

Corynoides calicularis, Cryptograptus tricornis, Dicellograptus sextans, Leptograptus flaccidus mut. *trentonensis.*

COLLECTION 126. Fort Peña formation 2⅞ miles S. 47° W. of Roberts ranch headquarters and 2⅞ miles S. 88° W. of the ruins of the Rock House at Rock House Gap.

Amplexograptus sp., *Climacograptus riddellensis?, Glyptograptus* cf. *G. teretiusculus.*

COLLECTION 127. Woods Hollow shale in a gulley 5⅜ miles S. 73° W. of Maravillas Gap.

Zone 12: *Climacograptus scharenbergi* cf. var. *stenostoma, Dicellograptus divaricatus, Dicellograptus divaricatus* var. *salopiensis, Dicellograptus sextans, Didymograptus serratulus, Glossograptus ciliatus?, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *euglyphus, Glyptograptus teretiusculus* var. *pygmaeus, Orthograptus calcaratus* var. *alabamensis, Orthograptus whitfieldi.*

COLLECTION 128. Maravillas chert 46 feet above the base of the formation on the east slope of the low hill 300 feet west of Collection 127.

Zone 13: *Climacograptus caudatus, Climacograptus typicalis* var. *crassimarginalis, Orthograptus calcaratus* var. *incisus, Orthograptus* aff. *O. truncatus, Cryptolithus* sp.

COLLECTION 129. Fort Peña formation 6⅞ miles S. 47° W. of Maravillas Gap.

Isograptus caduceus var. *maxima,* fragments of acrotretid brachiopods.

COLLECTION 130. Monument Spring dolomite member of the Marathon limestone in Section VI.

Zone 3: *Clonograptus* sp., *Tetragraptus approximatus.*

COLLECTION 131. Maravillas chert 176 feet above the base of the formation on a low ridge 3 miles northwest of Marathon.

Climacograptus sp., *Dicellograptus* sp., *Orthograptus calcaratus?, Diplograptus* sp.

COLLECTION 131A. Maravillas chert half a mile south of Collection 131.
Zone 14: *Climacograptus typicalis, Orthograptus calcaratus?, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Orthograptus truncatus* var. *recurrens.*

COLLECTION 132. Maravillas chert 225 feet below its contact with the Caballos novaculite, on a low ridge 5 miles N. 35° E. of Marathon.
Zone 14: *Climacograptus* sp., *Climacograptus caudatus, Dicellograptus pumilus, Orthograptus truncatus* var. *pertenuis, Orthograptus truncatus* var. *recurrens, Retiograptus pulcherrimus.*

COLLECTION 133. Maravillas chert 13 feet above the base of the formation in Section XV, measured on the cliff rising above the Picnic Grounds 5 miles south-southwest of Marathon.
Zone 13: *Climacograptus typicalis, Climacograptus typicalis* var. *crassimarginalis, Climacograptus* sp.

COLLECTION 134A. Maravillas chert 13 feet above Collection 133.
Zone 13: *Climacograptus antiquus, Climacograptus scharenbergi, Dicellograptus forchammeri* var. *flexuosus, Dicranograptus nicholsoni, Dicranograptus nicholsoni* var. *geniculatus, Orthograptus truncatus* var. *intermedius, Orthograptus quadrimucronatus* var. *angustus, Orthograptus quadrimucronatus* var. *cornutus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Retiograptus pulcherrimus, Orthograptus truncatus* var. *pertenuis.*

COLLECTION 134. Maravillas chert 6 feet above Collection 134A.
Zone 13: *Dicellograptus forchammeri* var. *flexuosus, Dicranograptus nicholsoni, Orthograptus* cf. *O. truncatus* var. *intermedius, Orthograptus* aff. *O. truncatus, Orthograptus* cf. *O. calcaratus* var. *vulgatus, Retiograptus pulcherrimus, Climacograptus antiquus, Climacograptus scharenbergi, Climacograptus spiniferus.*

COLLECTION 135. Maravillas chert at the base of the formation in Section XV.
Zone 13: *Climacograptus antiquus, Climacograptus typicalis* var. *crassimarginalis, Ampyxina* sp., *Cryptolithus* sp.

COLLECTION 136. Woods Hollow shale 57 feet below its contact with the Maravillas chert on Simpson Springs Mountain, one-fourth mile S. 17° E. of Simpson Springs.
Zone 12: *Climacograptus bicornis, Climacograptus parvus, Corynoides calicularis, Cryptograptus tricornis, Dicellograptus divaricatus, Dicellograptus divaricatus* var. *salopiensis, Dicellograptus gurleyi, Dicellograptus intortus, Dicellograptus sextans, Dicellograptus sextans* var. *exilis, Dicellograptus smithi, Glossograptus ciliatus?, Glyptograptus teretiusculus, Nemagraptus exilis* var. *linearis, Retiograptus geinitzianus.*

COLLECTION 137. Woods Hollow shale in a roadcut on the old Fort Stockton road, 2⅝ miles north of its junction with U.S. Highway 90.
Zone 11: *Climacograptus eximius, Climacograptus modestus* var. *meridionalis, Climacograptus parvus, Climacograptus riddellensis, Corynoides tricornis, Cryptograptus tricornis, Dicellograptus gurleyi, Dicellograptus gurleyi* var. *exilis, Dicellograptus patulosus, Didymograptus subtenuis, Glossograptus armatus, Glossograptus hincksii, Glyptograptus teretiusculus, Hallograptus bimucronatus, Nemagraptus exilis* var. *linearis, Nemagraptus gracilis* var. *surcularis, Retiograptus geinitzianus.*

COLLECTION 138. Maravillas chert 12 feet below its contact with the Caballos novaculite, on a low hill one-eighth mile east of the road to the Hess ranch, 6⅞ miles N. 17° E. of Marathon.
Zone 15: *Climacograptus mississippiensis, Climacograptus* cf. *C. ulrichi, Diplograptus crassitestus, Glyptograptus* sp.

COLLECTION 139. Woods Hollow shale 65 feet above the base of the formation 1¼ miles S. 84° W. of Peña Blanca Spring.
Zone 11: *Climacograptus eximius, Corynoides calicularis, Cryptograptus tricornis, Dicellograptus divaricatus, Dicellograptus gurleyi, Dicellograptus intortus, Dicellograptus moffatensis* var. *alabamensis, Dicellograptus sextans, Dicellograptus sextans* var. *exilis, Dicellograptus smithi, Glossograptus ciliatus?, Glyptograptus teretiusculus* var. *siccatus, Leptograptus flaccidus* mut. *trentonensis, Leptograptus validus* var. *incisus?, Nemagraptus gracilis, Nemagraptus exilis* var. *linearis, Retiograptus geinitzianus.*

COLLECTION 140. Fort Peña formation 18 feet above the base of the formation, 2½ miles N. 60° W. of Peña Blanca Spring.
Zone 8: *Cardiograptus crawfordi, Cardiograptus morsus, Dictyonema* sp., *Didymograptus pacificus, Isograptus caduceus* var. *victoriae, Oncograptus upsilon, Oncograptus upsilon* var. *biangulatus.*

COLLECTION 141. Fort Peña formation three-eighths mile southwest of Collection 140.
Zone 8: *Cardiograptus morsus, Didymograptus paraindentus, Didymograptus v-deflexus, Isograptus caduceus* var. *divergens, Isograptus caduceus* var. *maximo-divergens, Isograptus caduceus* var. *victoriae, Oncograptus upsilon, Oncograptus upsilon* var. *biangulatus, Phyllograptus typus.*

COLLECTION 142. Woods Hollow shale 2⅜ miles S. 53° W. of Gage's Lightning ranch and 1½ miles N. 40° W. of Peña Blanca Spring.
Eurychilina papillata, Eurychilina cf. *E. subradiata, Eurychilina* sp., *Schmidtella* sp.

COLLECTION 143. Maravillas chert 25 feet above the base of the formation on the northwest slope of the ridge rising above the road to Gage Indian Creek ranch (now owned by Gage Holland), 7 miles southwest of its junction with State Highway 51.
Zone 13: *Ampyxina* sp., fragments of bryozoa.

COLLECTION 144. Maravillas chert 112 feet above Collection 143.
Climacograptus sp., *Orthograptus* sp., *Cryptolithus* sp.

COLLECTION 145. Maravillas chert 20 feet above Collection 144.
Zone 14: *Hallopora* sp. and fragments of other bryozoa.

COLLECTION 146. Maravillas chert 5 feet above the base of the formation, from the matrix of the basal conglomerate, in Section XIV, measured at Rock House Gap.
Zone 13: *Streptelasma* sp.

COLLECTION 147. Maravillas chert 8 inches below its contact with the Caballos novaculite at Monument Spring on the southeast limb of the Marathon anticlinorium.
Zone 15: *Climacograptus putillus, Climacograptus scalaris* var. *miserabilis?, Climacograptus* cf. *C. ulrichi, Dicellograptus complanatus, Dicellograptus complanatus* var. *arkansasensis, Diplograptus crassitestus, Glyptograptus* sp., *Orthograptus truncatus* var. *abbreviatus?*.

COLLECTION 148. Woods Hollow shale 75 feet above the base of the formation in Section XI.
Zone 11: *Dicellograptus intortus, Dicellograptus sextans, Glyptograptus teretiusculus* var. *euglyphus, Nemagraptus exilis* var. *linearis.*

COLLECTION 149. Fort Peña formation 60 feet above the base of the formation in Section XVIII.
Zone 9: *Glossograptus acanthus, Glossograptus hincksii, Glyptograptus* sp., *Hallograptus echinatus, Hallograptus etheridgei.*

COLLECTION 150. Woods Hollow shale half a mile south of Ridge Spring, on the section of old highway between Ridge Spring and Garden Springs.
Zone 11: *Climacograptus scharenbergi* cf. var. *stenostoma, Cryptograptus tricornis, Dicellograptus intortus, Dicellograptus moffatensis* var. *alabamensis, Dicellograptus sextans, Glyptograptus teretiusculus, Glyptograptus teretiusculus* var. *euglyphus.*

COLLECTION 151. Woods Hollow shale one-fourth mile south of Collection 150.
Fragments of bryozoa, brachiopods, and trilobites.

COLLECTION 152. Fort Peña formation 1¼ miles S. 7° W. of Garden Springs and one-eighth mile west of the abandoned section of highway.
Zone 9: *Didymograptus nodosus, Didymograptus* sp., *Glyptograptus* cf. *G. austrodentatus, Isograptus caduceus* var. *imitata. Isograptus* sp., *Pterograptus incertus.*

Plates 4–20

FAUNA OF GRAPTOLITE ZONES 1–15

All figures on Plates 4 to 18 are untouched photographs. The specimens were photographed while under glycerin with the exception of the following, which were photographed dry: Plate 6, figures 3 and 8; Plate 7, figures 1–3, 5, 9; Plate 8, figure 15; Plate 16, figures 2, 6–13.

The figures on Plates 19 and 20 are drawings made from specimens which show little contrast with the rock background.

PLATE 4

ZONE 1

All figures x2 except figure 6 which is x10 and figure 7 which is x6

FIGURES— PAGE

1, 2. *Clonograptus* cf. *C. tenellus* (Linnarson). Collection 119 48
Figure 1. YPM 20258.
Figure 2. YPM 20259.

3. Fragments of *Clonograptus* cf. *C. tenellus* (Linnarson) and *Anisograptus* sp. Collection 119, YPM 20260 48

4, 9. *Anisograptus* sp. Collection 72B.
Figure 4. YPM 20261.
Figure 9. YPM 20264.

5, 6. *Anisograptus dissolutus* Berry, n.sp. Holotype. Collection 84A, YPM 20255. In figure 6, the arrow points at the sicula 45

7. *Triograptus* cf. *T. otagoensis* Benson and Keble. Collection 72D, YPM 20262 48

8. *Dictyonema* sp. Collection 29, YPM 20263.

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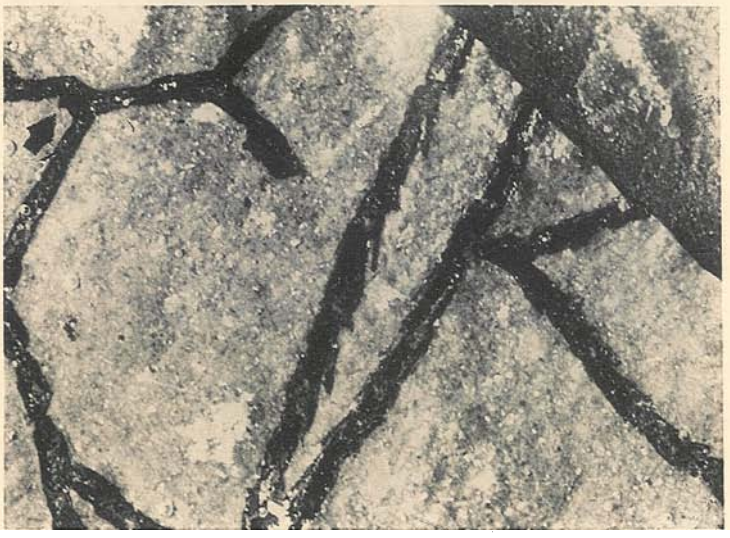

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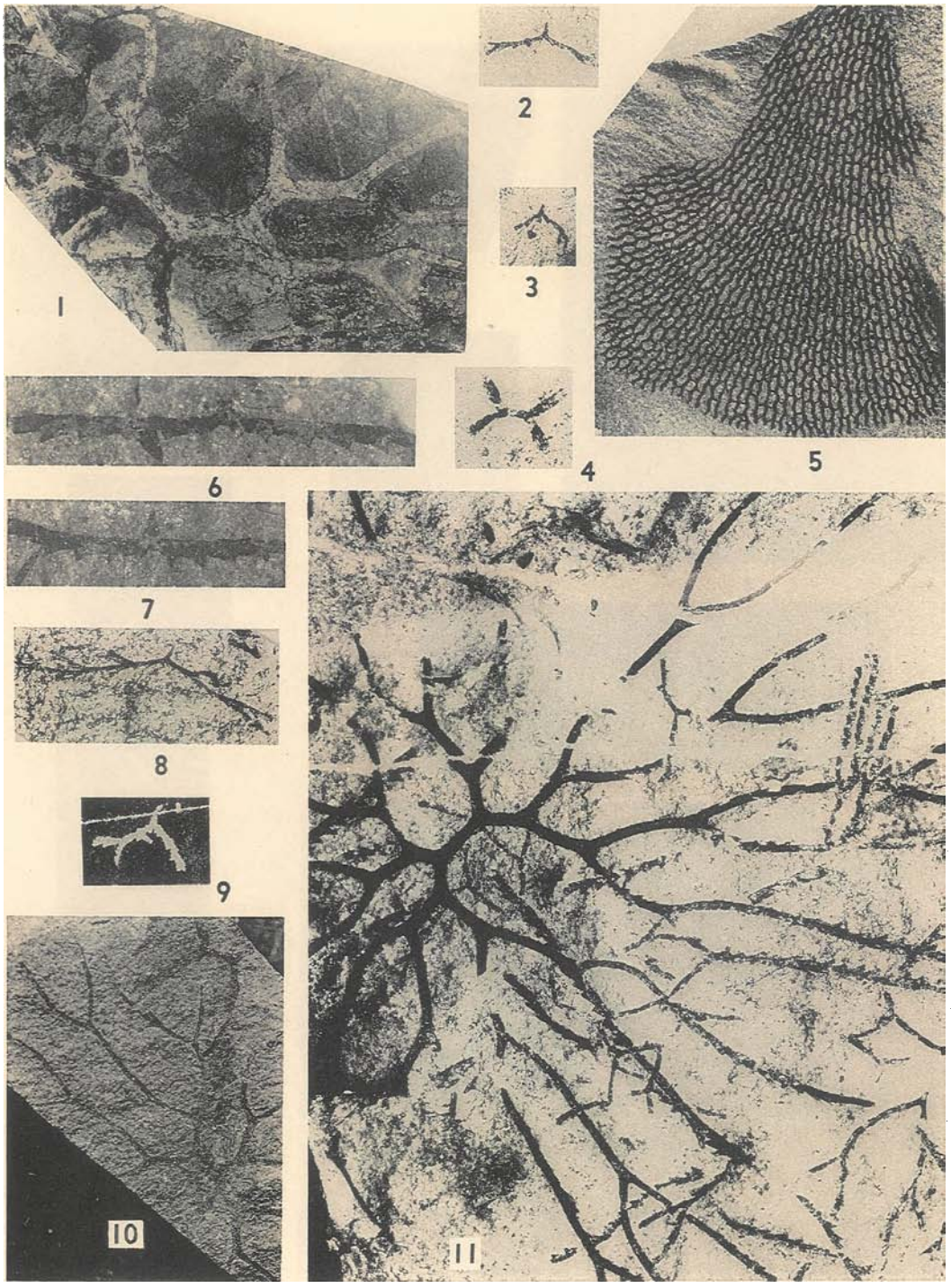
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PLATE 5

ZONE 2

All figures x2 except figures 6 and 7 which are x6

FIGURES— PAGE

1. *Clonograptus* sp. Collection 12, YPM 20265.
2, 8. *Adelograptus hunnebergensis* (Moberg)? 45–46
   Figure 2. Collection 11, YPM 20266.
   Figure 8. Collection 59, YPM 20271.
3. *Adelograptus* sp. Collection 59B, YPM 20267.
4. *Tetragraptus decipiens* T. S. Hall. Collection 84, YPM 20268.
5. *Dictyonema* sp. Collection 97B, YPM 20269.
6, 7. *Didymograptus novus* Berry, n.sp. Holotype. Collection 72D 62
   Figure 6. YPM 20254.
   Figure 7. YPM 20270.
9. *Bryograptus crassus* Harris and Thomas?. Collection 33, YPM 20272 47
10. *Clonograptus rigidus* (Hall). Collection 84, YPM 20273 48
11. *Clonograptus persistens* Harris and Thomas. Collection 33, YPM 20274 47

PLATE 6

ZONE 3

All figures x2

FIGURES— PAGE

1–3. *Tetragraptus approximatus* (Nicholson) 52
Figure 1. Collection 76, YPM 20275.
Figure 2. Collection 76, YPM 20276.
Figure 3. Collection 120.

4. *Clonograptus flexilis* (Hall). Collection 76, YPM 20277 47

5. *Didymograptus extensus* (Hall). Collection 79, YPM 20278 60

ZONE 5

6. *Tetragraptus serra* (Brongniart). Collection 26, YPM 20279 56

7, 11, 12. *Tetragraptus fruticosus* (Hall) 54
Figure 7. Three-branched form. Collection 90, YPM 20280.
Figure 11. Three-branched form. Collection 27, YPM 20283.
Figure 12. Four-branched form. Collection 27.

8. *Protopliomerops* sp. Collection 26.

9. *Didymograptus patulus* (Hall). Collection 32, YPM 20281 63

10. *Tetragraptus amii* Lapworth. Collection 26, YPM 20282 52

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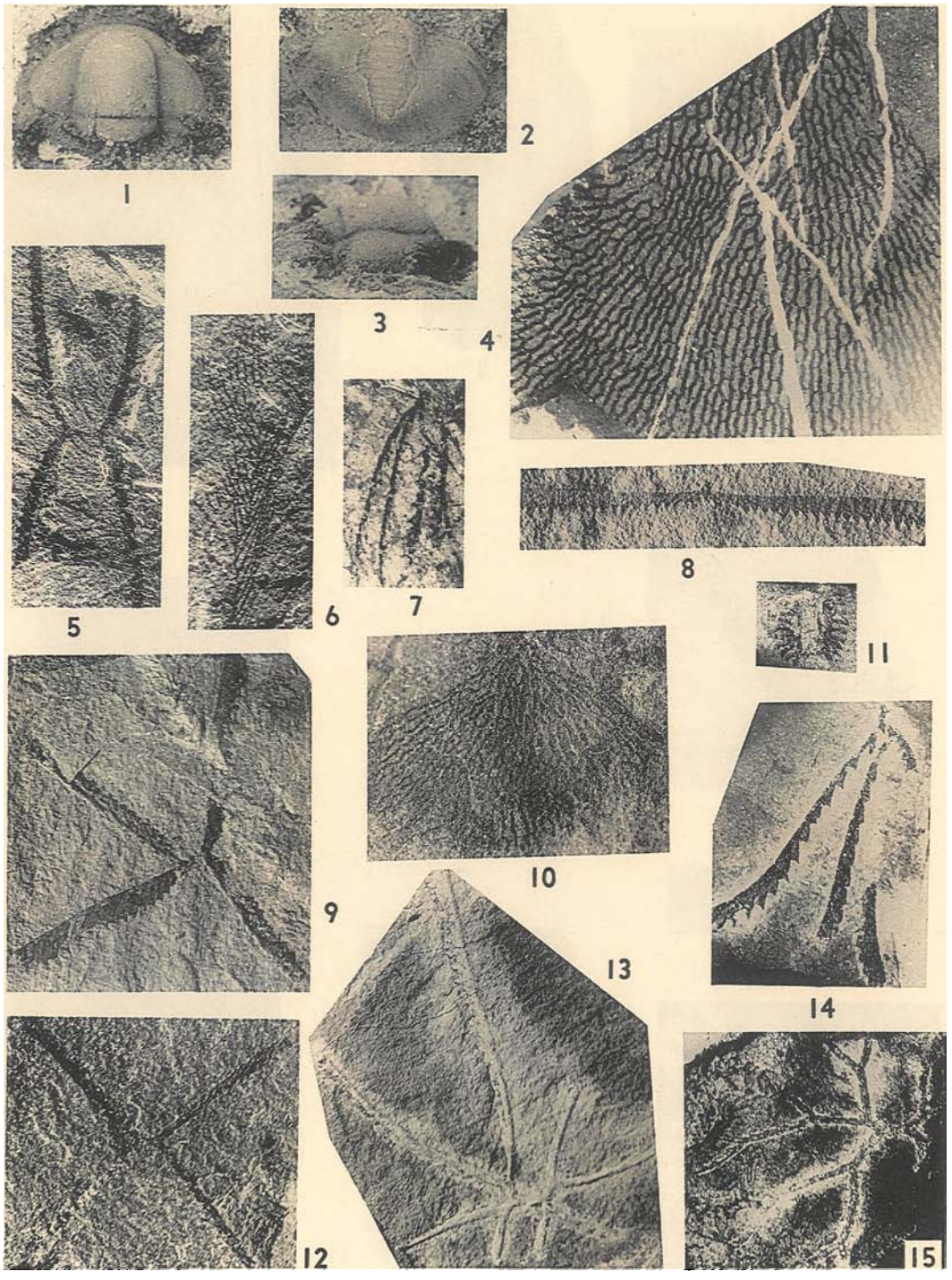
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PLATE 7

ZONE 4

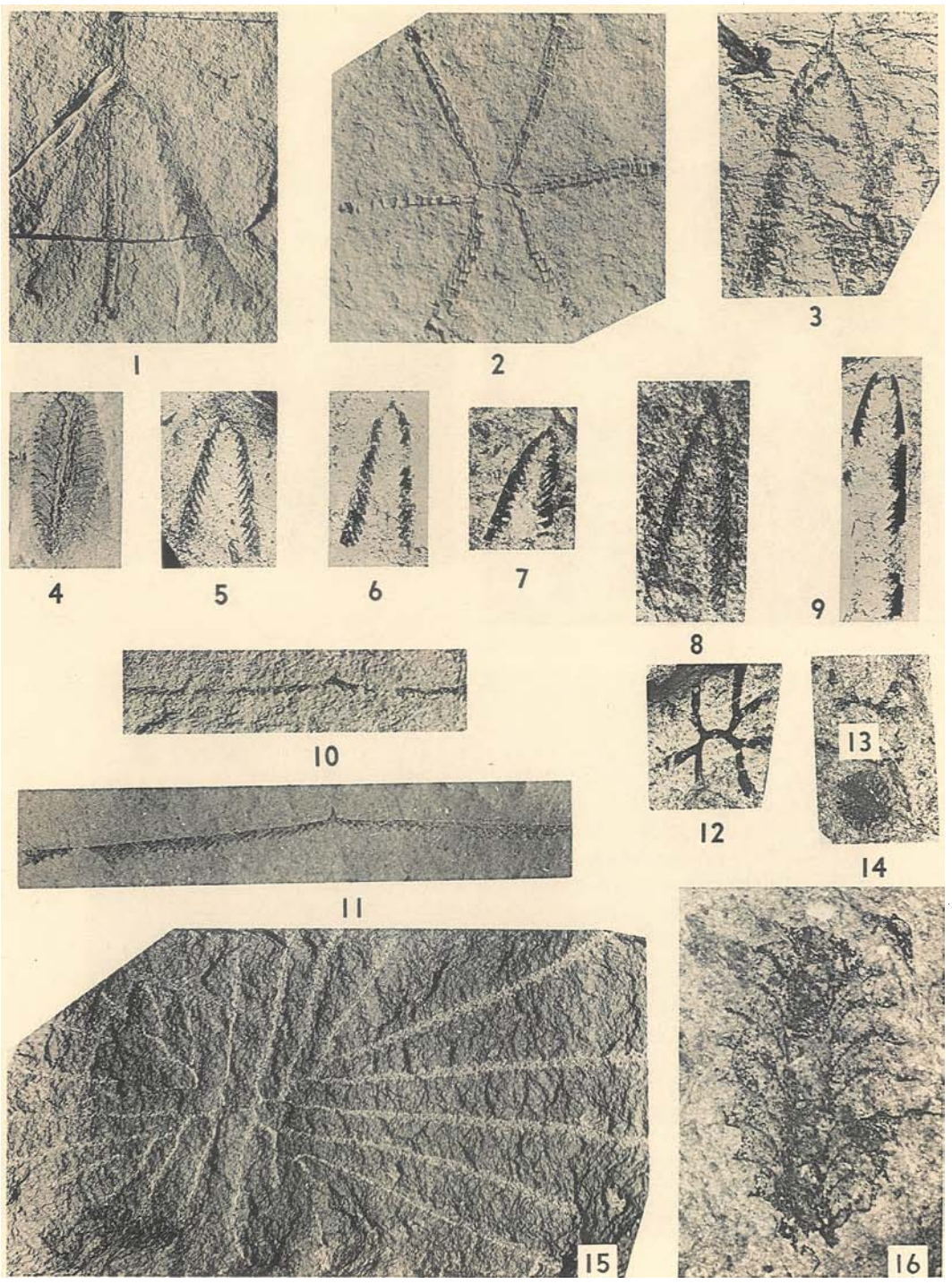
All figures x2 except figure 1 which is x3

FIGURES—		PAGE
1–3.	New genus related to *Benthamaspis* and *Strigenalis*. Collection 79. Figure 1. Glabella. Figure 2. Pygidium. Figure 3. View of glabella from right side.	
4.	*Dictyonema* sp. Collection 101, YPM 20284.	
5.	*Tetragraptus acclinans* Keble. Collection 48	52
6.	*Ptilograptus plumosus* Hall. Collection 121, YPM 20285	49
7.	*Tetragraptus pendens* Elles. Collection 71, YPM 20286	55
8.	*Didymograptus patulus* (Hall). Collection 69	63
9.	*Tetragraptus amii* Lapworth. Collection 69	52
10.	*Dictyonema dumosus* Berry, n.sp. Holotype. Collection 101, YPM 20251	45
11.	*Tetragraptus bigsbyi* (Hall). Collection 71, YPM 20287	53
12.	*Tetragraptus quadribrachiatus* (Hall). Collection 121, YPM 20288	55
13.	*Dichograptus octobrachiatus* (Hall). Collection 69, YPM 20289	51
14.	*Tetragraptus fruticosus* (Hall) (4-branched form). Collection 69, YPM 20290	54
15.	*Clonograptus rigidus* (Hall). Collection 69, YPM 20291	48

PLATE 8

ZONE 6

All figures x2 except figure 16 which is x10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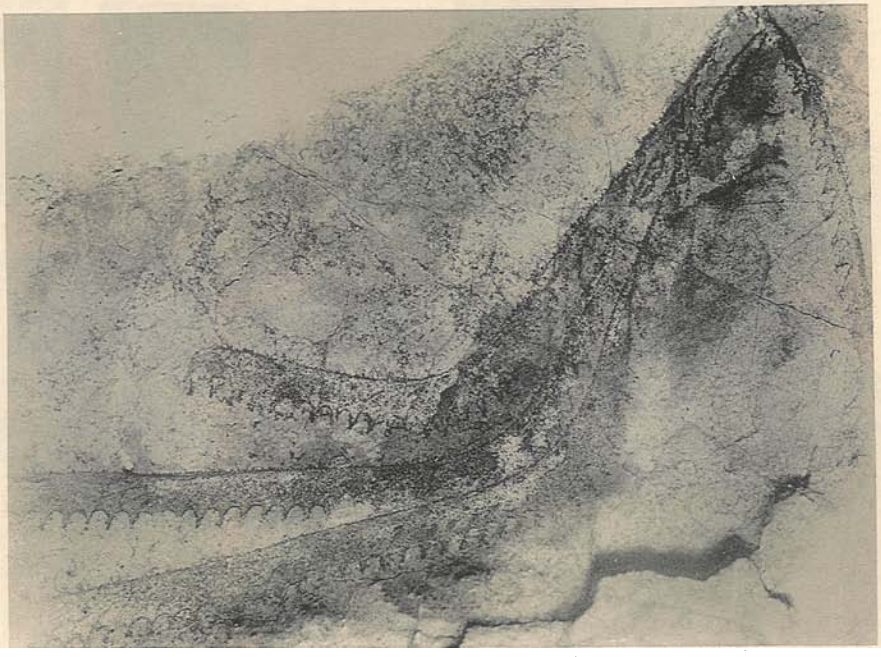

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PLATE 9

All figures x2

FIGURES— PAGE

1, 2. *Phyllograptus ilicifolius* Hall. Collection 26 57
Figure 2. YPM 20307.

3. *Tetragraptus fruticosus* (Hall) (4-branched form). Collection 114, YPM 20306..... 54

PLATE 10

ZONE 7

All figures x2 except figure 2 which is x10

FIGURES— PAGE

1, 11, 13. *Phyllograptus typus* Hall 58

Figure 1. Collection 70, YPM 20308.
Figure 11. Collection 47, YPM 20316.
Figure 13. Collection 70, YPM 20317.

2, 5, 6. *Didymograptus artus* Elles and Wood. Collection 20 58

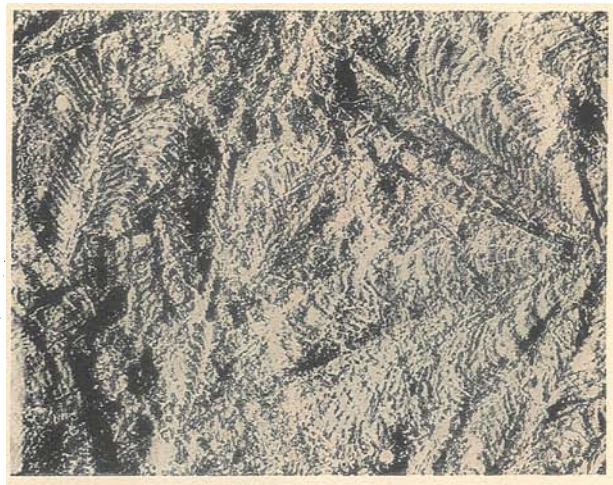
Figures 2, 6. YPM 20309.
Figure 5. YPM 20312.

3, 7–10. *Didymograptus bifidus* (Hall) 59

Figure 3. Collection 9, YPM 20310.
Figure 7. Collection 19, YPM 20313.
Figure 8. Collection 67.
Figure 9. Collection 67, YPM 20314.
Figure 10. Collection 20, YPM 20315.

4. *Phyllograptus anna* Hall. Collection 47, YPM 20311 57

12. *Didymograptus denticulatus* Berry, n.sp. Holotype. Collection 20, YPM 20252 60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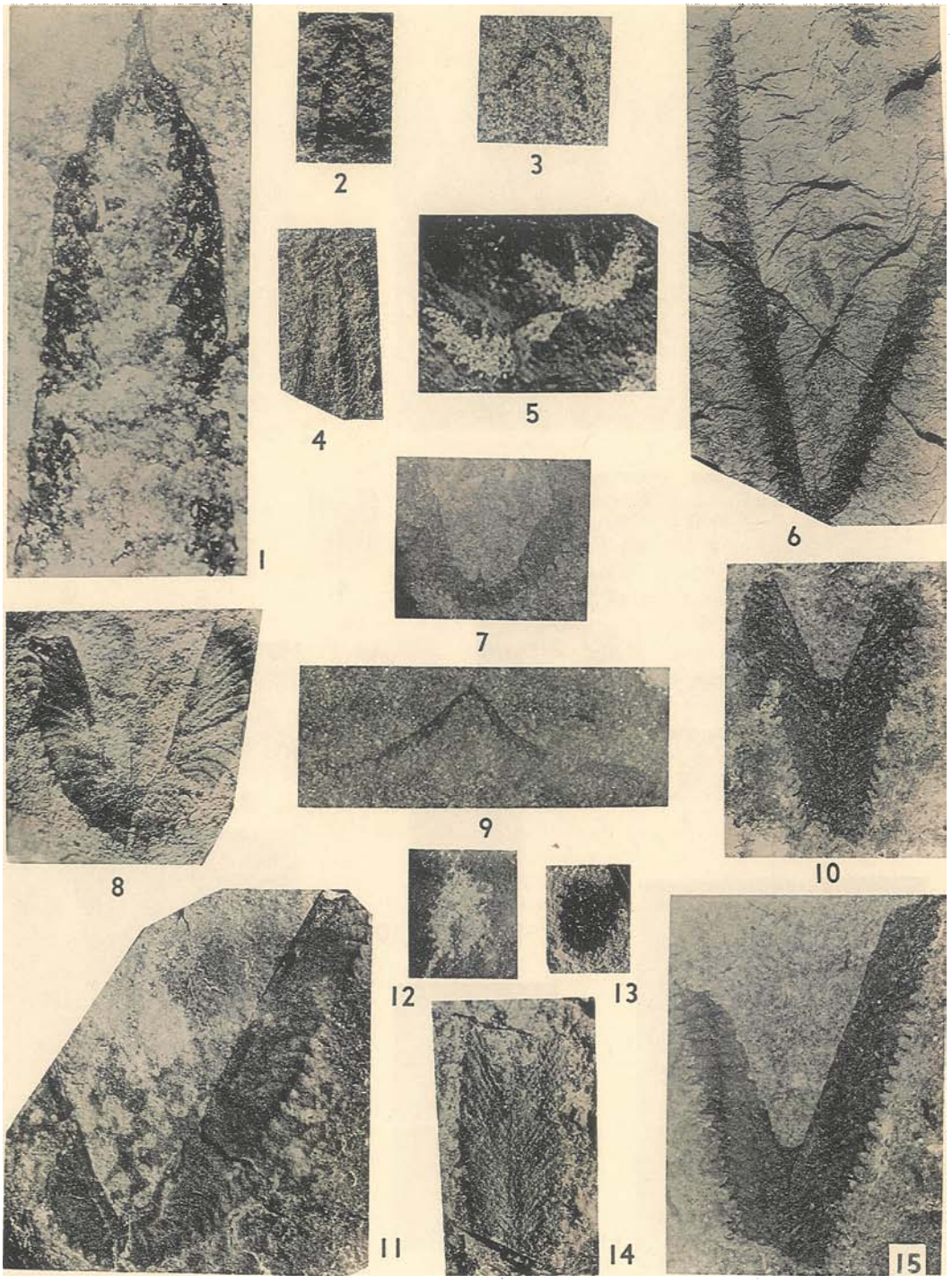
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PLATE 11

ZONE 8

All figures x2 except figure 1 which is x10

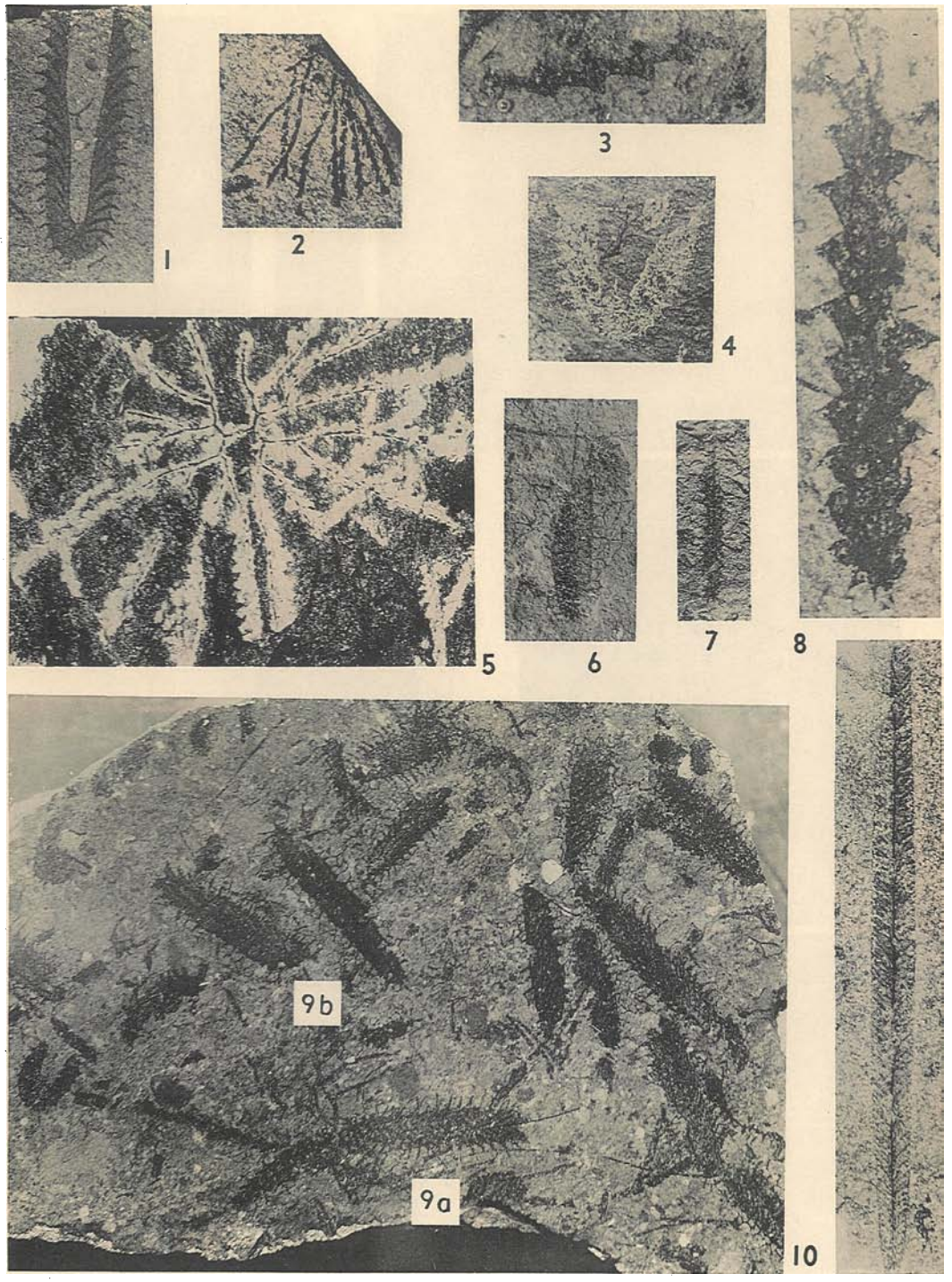
PLATE 12

ZONE 9

All figures x2 except figures 3 and 8 which are x10

FIGURES— PAGE

1. *Isograptus forcipiformis* var. *latus* Ruedemann. Collection 28, YPM 20328 67
2. *Pterograptus incertus* Harris and Thomas. Collection 16, YPM 20329 51
3. *Didymograptus nodosus* Harris. Fragment of a stipe. Collection 98, YPM 20330..... 62
4. *Isograptus manubriatus* (T. S. Hall). Collection 111 67
5. *Loganograptus logani* mut. *pertenuis* Ruedemann. Collection 28, YPM 20331 50
6. *Hallograptus etheridgei* (Harris). Collection 149 95
7, 8. *Cryptograptus schaferi* (Lapworth). Collection 15, YPM 20332 69
9. Typical assemblage of Zone 9. Collection 13.
   - 9a. *Glossograptus hincksii* (Hopkinson). YPM 20381 71
   - 9b. *Hallograptus etheridgei* (Harris). YPM 20382 95
10. *Trigonograptus ensiformis* (Hall). Collection 28, YPM 20333 94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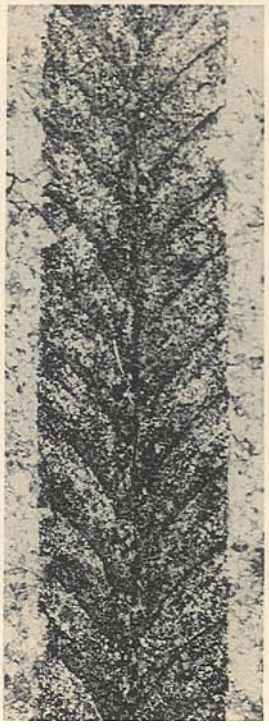


6

7

PLATE 13

ZONE 9

FIGURES— PAGE

1. Typical assemblage of Zone 9, x2. Collection 28.
   Tetragraptus serra (Brogniart). YPM 20380 56
   Tetragraptus? sp., dendroid fragment.

2, 3. *Glyptograptus* cf. *G. austrodentatus* (Harris and Keble). Collection 117, YPM 20334.. 87
   Figure 2, x2; figure 3, x16.

4. *Hallograptus etheridgei* (Harris), x10. Proximal end. Collection 13, YPM 20382..... 95

5. *Dichograptus marathonensis* Berry, n.sp., x2. Holotype. Collection 28, YPM 20257.... 51

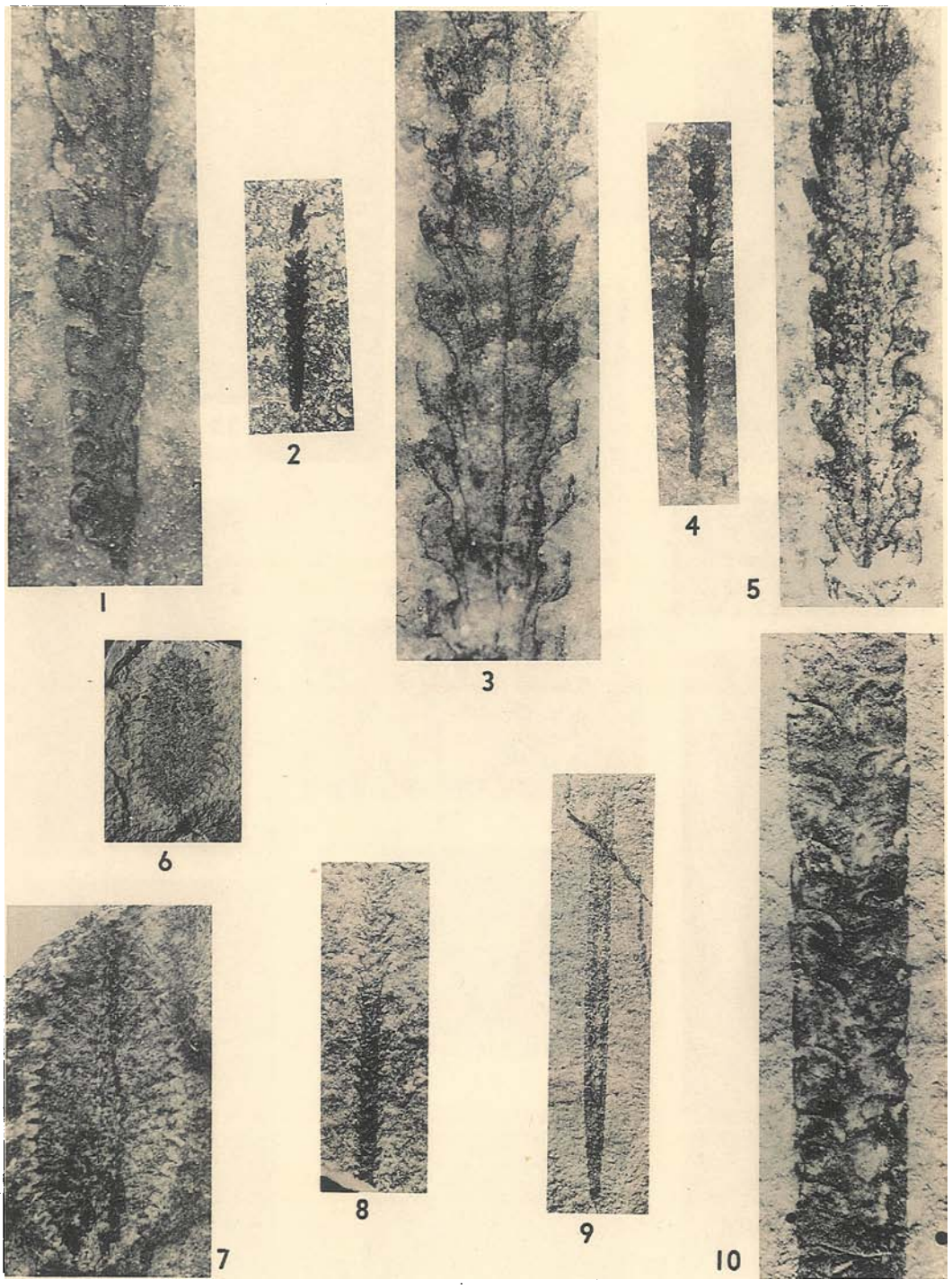
6, 7. *Trigonograptus ensiformis* (Hall). Collection 28 94
   Figure 6, x10. YPM 20336.
   Figure 7, x2. YPM 20335.

PLATE 14

ZONE 10

Figures 2, 4, 6–9, all x2. Figures 1, 3, 5, 10, all x10

FIGURES—		PAGE
1, 2.	*Amplexograptus confertus* (Lapworth). Obverse aspect. Collection 38, YPM 20337	85
3–5, 8.	*Glyptograptus* cf. *G. teretiusculus* (Hisinger). Reverse aspect. Collection 85	87
	Figures 3, 8. YPM 20338. Figures 4, 5. YPM 20339.	
6, 7.	*Phyllograptus nobilis* Harris and Keble. Collection 85	57
9, 10.	*Climacograptus riddellensis* Harris. Collection 46	82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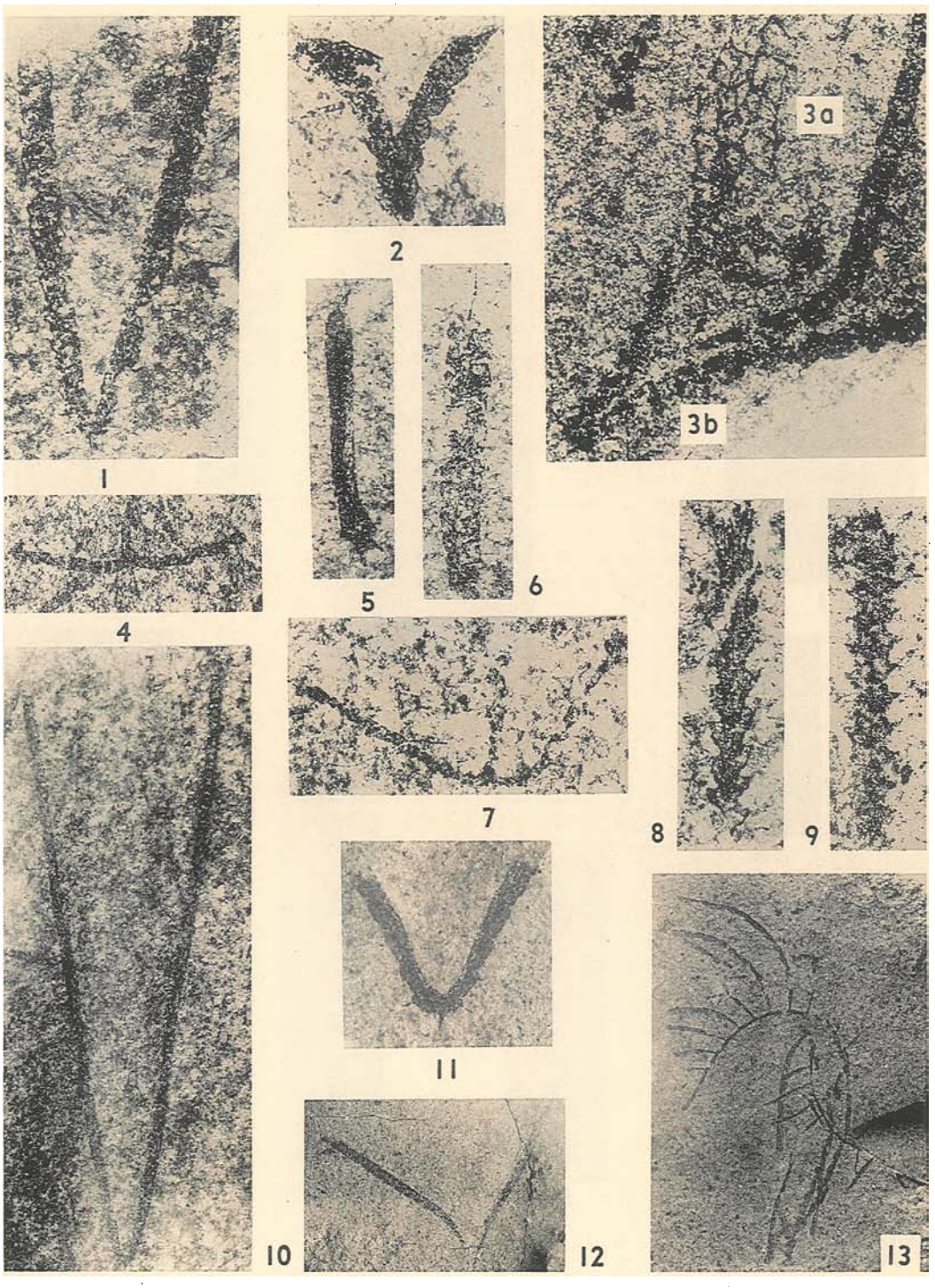
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11
12
13

PLATE 15

ZONE 11

All figures x6 except figures 10, 12, 13 which are x2

FIGURES— PAGE

1. *Dicellograptus intortus* Lapworth. Collection 122, YPM 20340 75
2. *Dicranograptus brevicaulis* Elles and Wood. Collection 104, YPM 20341 77
3a. *Retiograptus geinitzianus* Hall. Collection 136, YPM 20379 96
3b. *Dicellograptus smithi* Ruedemann. Collection 136, YPM 20378 77
4. *Leptograptus* sp. Collection 139, YPM 20342.
5. *Corynoides calicularis* Nicholsoni. Collection 104, YPM 20343 68
6. *Climacograptus scharenbergi* cf. var. *stenostoma* Bulman. Collection 127, YPM 20344 83
7. *Leptograptus flaccidus* mut. *trentonensis* Ruedemann. Collection 139, YPM 20345..... 72
8. *Glyptograptus teretiusculus* var. *euglyphus* (Lapworth). Collection 127, YPM 20346.. 88
9. *Cryptograptus tricornis* (Carruthers). Collection 136, YPM 20347 70
10. *Dicellograptus moffatensis* var. *alabamensis* Ruedemann. Collection 139, YPM 20348 76
11. *Dicellograptus sextans* var. *exilis* Elles and Wood. Collection 104, YPM 20349 77
12. *Dicellograptus divaricatus* (Hall). Collection 104, YPM 20350 74
13. *Nemagraptus gracilis* (Hall). Collection 139, YPM 20351 73

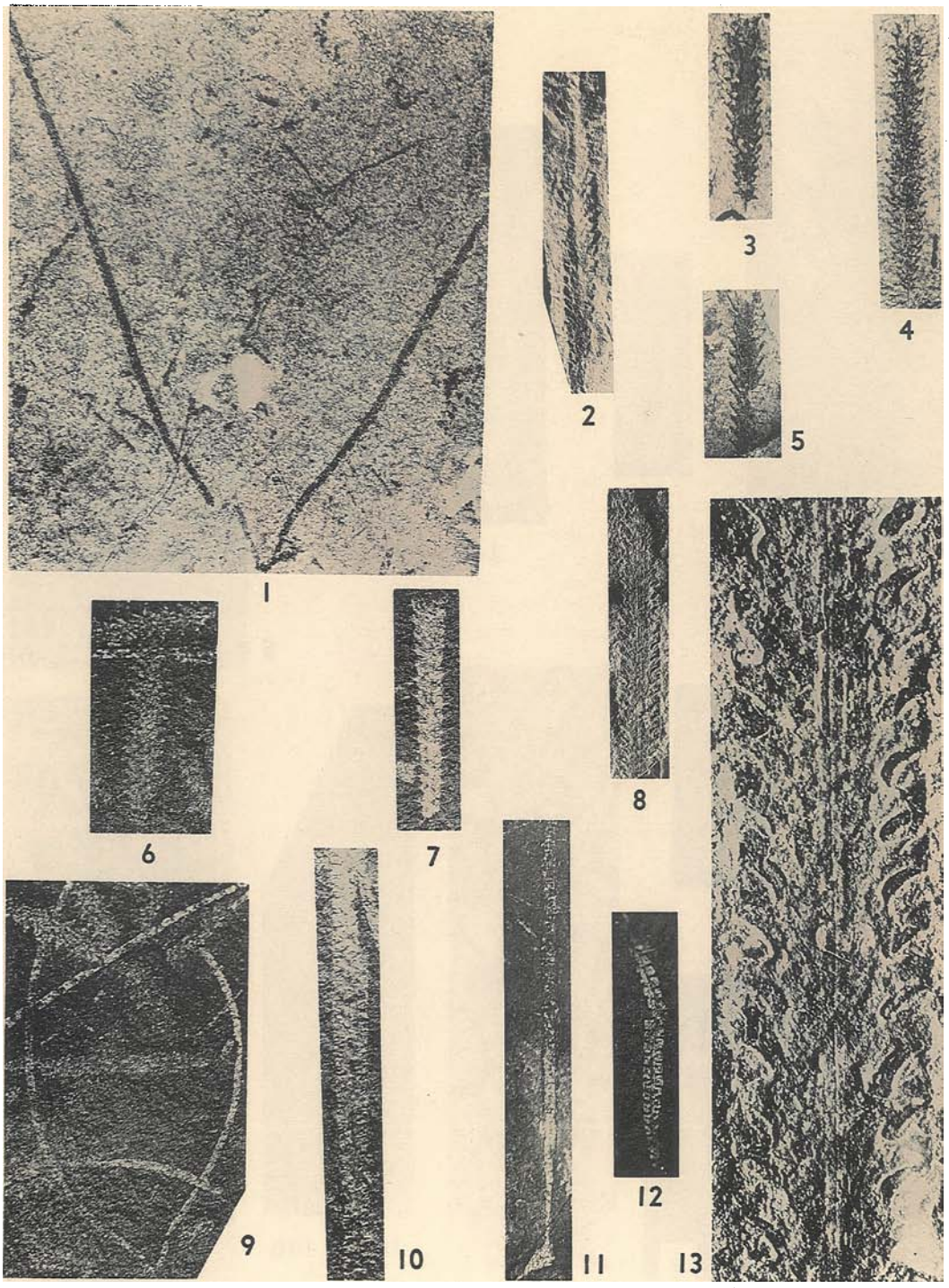
PLATE 16

ZONE 12

All figures x2 except figure 13 which is x10

FIGURES— PAGE

1. *Dicellograptus divaricatus* var. *salopiensis* Elles and Wood. Collection 136, YPM 20352 72
2. *Diplograptus multidens* (Elles and Wood). Collection 87, YPM 20353 85
3, 4. *Orthograptus calcaratus* var. *acutus* Lapworth. Collection 94A 89
   Figure 3. YPM 20354.
   Figure 4. YPM 20355.
5. *Glytograptus teretiusculus* (Hisinger). Collection 94C, YPM 20356 87
6. *Hallograptus mucronatus* (Hall). Collection 87, YPM 20357 95
7. *Orthograptus whitfieldi* (Hall). Collection 94A 93
8, 13. *Amplexograptus* cf. *A. perexcavatus* (Lapworth). Obverse aspect. Collection 87, YPM 20358 86
9. *Dicellograptus gurleyi* Lapworth. Collection 136, YPM 20359 75
10, 11. *Climacograptus bicornis* (Hall). Collection 87 79
   Figure 10. Distal portion of stipe. YPM 20360.
   Figure 11. YPM 20361.
12. *Climacograptus parvus* Hall. Collection 94B, YPM 20362 81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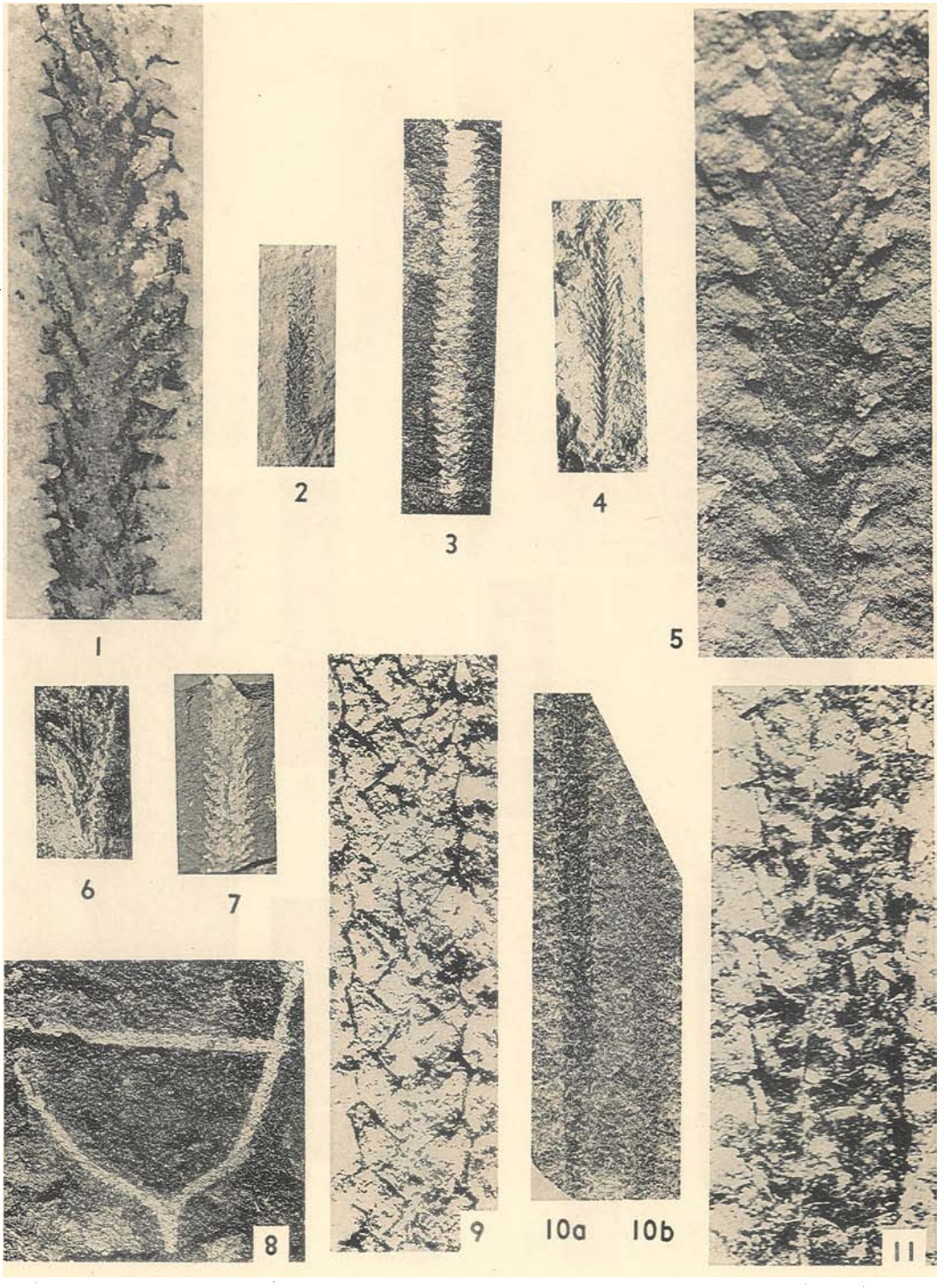
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10a
10b
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PLATE 17

ZONE 13

Figures 2–4, 6–8, 10a-b, all x2. Figures 1, 5, 9, 11, all x10

FIGURES— PAGE

1, 2. *Climacograptus typicalis* var. *crassimarginalis* Ruedemann and Decker. Collection 106, YPM 20363 84

3, 7. *Orthograptus calcaratus* var. *incisus* (Lapworth). Collection 128 90

Figure 3. YPM 20364.
Figure 7. YPM 20366.

4, 5. *Orthograptus truncatus* var. *intermedius* (Elles and Wood). Collection 134A 92

6. *Dicranograptus nicholsoni* Hopkinson. Collection 134A, YPM 20365 78

8. *Dicranograptus nicholsoni* var. *geniculatus* Ruedmann and Decker. Collection 134A, YPM 20367 78

9, 10b. *Retiograptus pulcherrimus* Keble and Harris. Collection 73, YPM 20368 96

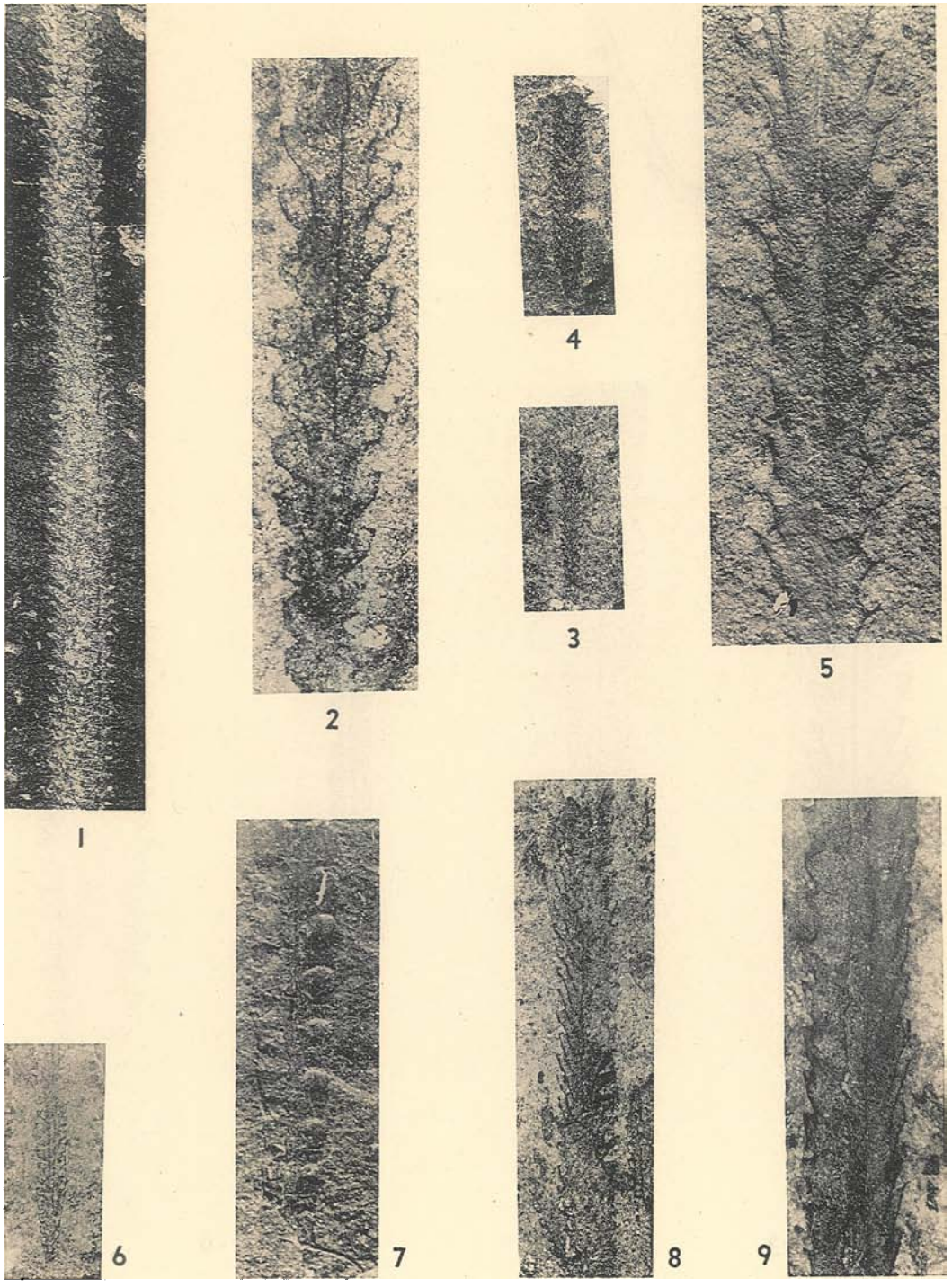
10a, 11. *Orthograptus quadrimucronatus* var. *angustus* (Ruedemann). Collection 73, YPM 20369 91

PLATE 18

ZONE 14

FIGURES— PAGE

1. *Orthograptus quadrimucronatus* (Hall), x2. Collection 73A, YPM 20370 91
2, 3. *Diplograptus minutus* Berry, n.sp. Holotype. Collection 45, YPM 20256 85
Figure 2, x10.
Figure 3, x2.
4, 5. *Orthograptus truncatus* var. *recurrens* (Ruedemann) 93
Figure 4, x2. Collection 131A.
Figure 5, x10. Collection 132.
6. *Climacograptus* sp., x2. Collection 45, YPM 20371.
7. *Climacograptus caudatus* Lapworth, x10. Collection 128 79
8. *Orthograptus* cf. *O. calcaratus* var. *vulgatus* (Lapworth), x2. Collection 45, YPM 20272 90
9. *Orthograptus calcaratus* (Lapworth) ?, x5. Collection 131, YPM 20373 89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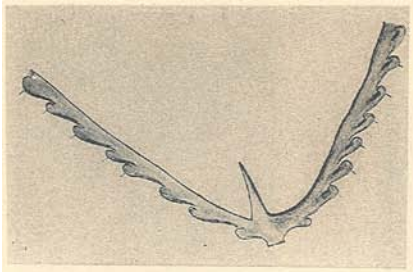

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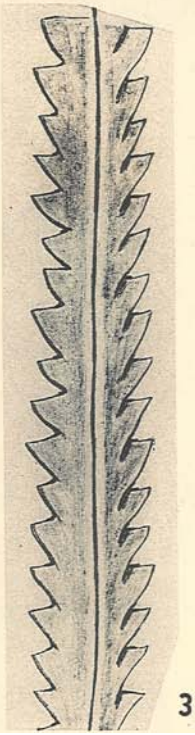

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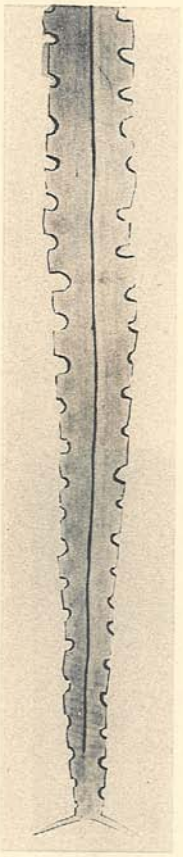

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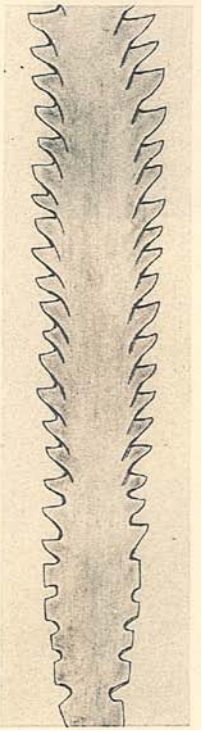


6

PLATE 19

All figures x5

FIGURES— PAGE

1. *Dicellograptus forchammeri* var. *flexuosus* Lapworth. Collection 134 75
2. *Climacograptus minimus* (Carruthers). Collection 83B, YPM 20384 80
3. *Orthograptus* cf. *O. calcaratus* var. *basilicus* (Lapworth). Collection 83A 90
4. *Climacograptus bicornis* (Hall). Collection 87, YPM 20385 79
5. *Climacograptus tubuliferus* Lapworth. Collection 55, YPM 20386 83
6. *Diplograptus multidens* (Elles and Wood). Collection 87 85

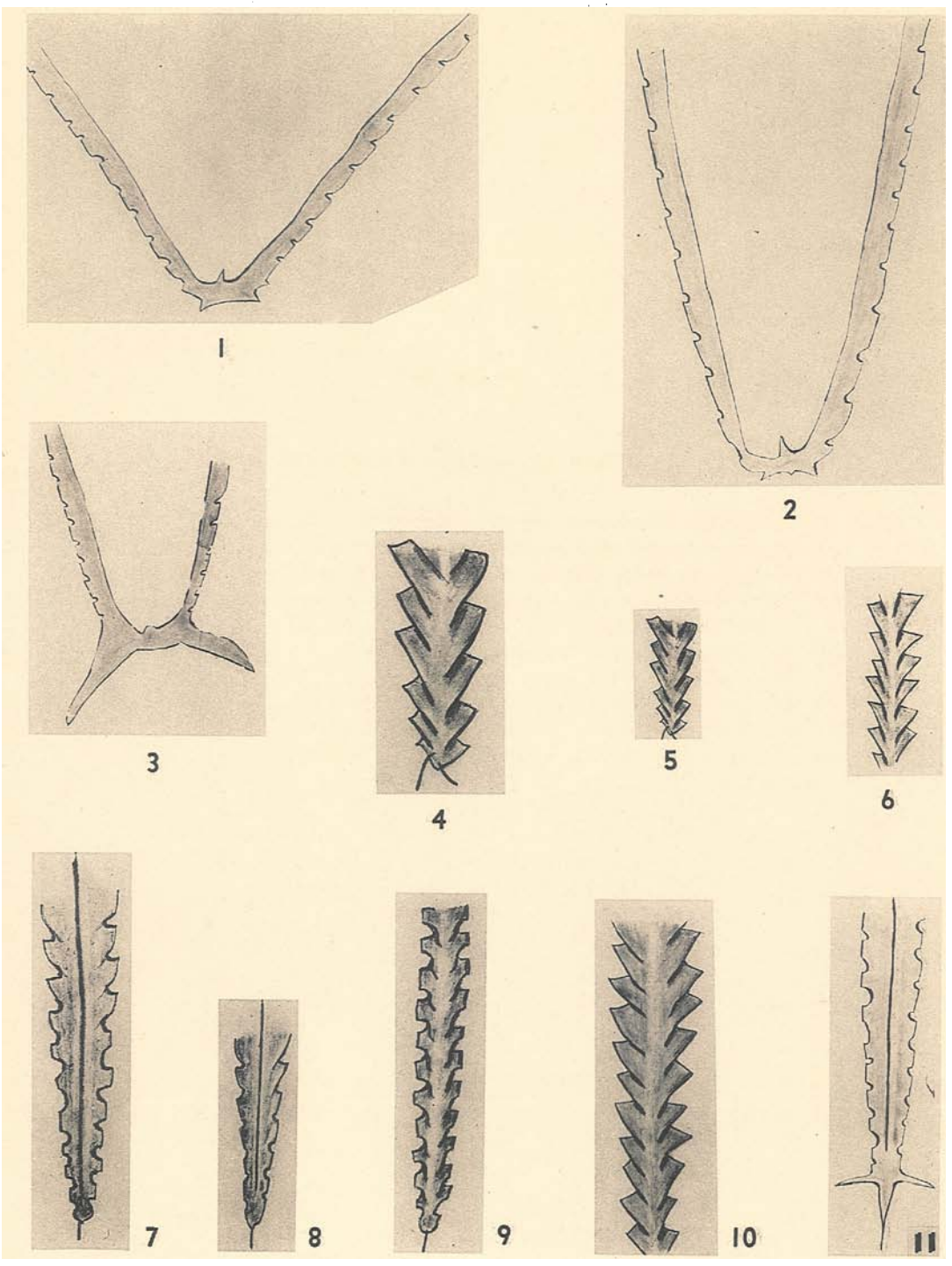
PLATE 20

ZONE 15

All figures x5 except figure 4, which is x10

FIGURES— PAGE

1. *Dicellograptus complanatus* Lapworth. Collection 60 73
2. *Dicellograptus complanatus* var. *arkansasensis* Ruedemann. Collection 60, YPM 20383 73
3. *Dicellograptus complanatus* var. *ornatus* Elles and Wood. Collection 60, YPM 20374 74
4–6. *Orthograptus truncatus* var. *socialis* (Lapworth). Collection 60 93
   Figure 6. YPM 20375.
7, 8. *Diplograptus crassitestus* (Ruedemann). Collection 60 84
   Figure 8. YPM 20376.
9. *Climacograptus mississippiensis* Ruedemann. Collection 138 81
10. *Orthograptus truncatus* var. *abbreviatus* (Elles and Wood) ?. Collection 147..... 92
11. *Climacograptus hastatus* T. S. Hall. Collection 60, YPM 20377 80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11

Index

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GRAPTOLITE FAUNAS,
MARATHON REGION
PLATE I

INDEX MAP SHOWING POSITION OF MEASURED SECTIONS AND FOSSIL COLLECTING LOCALITIES BREWSTER COUNTY, TEXAS

William B. N. Berry

Scale

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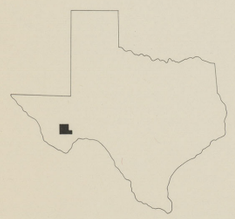

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Base from USGS Topographic Quadrangle Maps

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